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NWFT/DVM
Self-Teaching Curriculum

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ABSTRACT

This document contains a series of lecture notes, sample problems and solutions for the NWFT/DVM (Network Flow and Transport/Distributed Velocity Method) model which was developed at Sandia National Laboratories for the Risk Methodology for Geologic Disposal of Radioactive Waste program (NRC FIN A-1192). The purpose of these notes and problems is to familiarize the student with the code, its capabilities and its limitations. When the student has completed this curriculum, he or she should be able to prepare data input for NWFT/DVM and have some insights into interpretation of the model output. This report represents one of a series of self teaching curricula prepared under a technology transfer contract for the U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management (FIN A-1158).

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NWFT/DVM SELF TEACHING

Curriculum

LECTURE NOTES

I. INTRODUCTION

The purpose of this course is to develop familiarity with the Network Flow and Transport/Distributed Velocity Method (NWFT/DVM) model. After completing this course, the student should understand the mathematical models used in the network flow model and should understand the basic concepts underlying the Distributed Velocity Method (DVM). The course will use lectures and discussion to provide insight into the mathematical models. Sample problems will be used to provide familiarity with NWFT/DVM input and output and to illustrate numerical criteria required to assure accuracy when the DVM transport option is used.

NWFT/DVM was developed from the NWFT model* primarily by adding an option to perform radionuclide transport using DVM. As was pointed out, the NWFT model has the following limitations:

*J. E. Campbell and others, "Risk Methodology for Geologic Disposal of Radioactive Waste: The Network Flow and Transport (NWFT) Model, "NUREG/CR-1190 and SAND79-1920, Sandia National Laboratories, Albuquerque, New Mexico, February, 1980.

N. C. Finley and others, "NWFT Self-Teaching Curriculum," US NRC Accession No. , SAND81-0372, Sandia National Laboratories, Albuquerque, New Mexico, August, 1981.

(1) it can only treat chains of three isotopes or less, (2) all isotopes must have the same distribution coefficient and (3) solubility limits are not accounted for. Addition of the DVM transport option has removed these limitations. The network flow model has also been modified in NWFT/DVM to account for brine effects on fluid flow.

The NWFT/DVM flow model will be presented first followed by a review of the analytic transport option. These discussions will be followed by sample problems which illustrate the flow model and the analytic transport option. The remainder of the course will deal with the DVM transport option. The basic concepts underlying DVM will be discussed. The source and discharge models and criteria for space-step and time-step selection will be presented. Sample problems for NWFT/DVM are included at the close of the lecture notes. Specific sample problems can be worked after a certain portion of the descriptive material has been presented. The text indicates at what points each sample problem can be attempted.

DVM /STC

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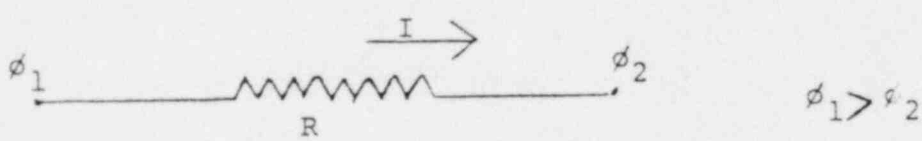
Notebook Divider Should Read: NWFT/DVM FLOW MODEL.

II. THE NWFT/DVM FLOW MODEL

The Electrical Analog

NWFT/DVM uses a network representation to simulate two-dimensional fluid flow at the reference site. Before discussing the flow model in NWFT/DVM, it may be useful to briefly review the concept of the electrical network analog for representation of fluid flow systems. Consider the figure below.



Single Resistor

Figure 1.

This simple circuit represents a single resistor. The voltage drop across the resistor is $\phi_1 - \phi_2$. According to Ohm's law, the current through the resistor is given by

$$I = (\phi_1 - \phi_2)/R \qquad 1.$$

If ϕ_1 and ϕ_2 are expressed in volts and R is express in ohms, then the units of I are amperes.

Suppose we replace the resistor in Figure 1 with a length of resistive material as indicated in Figure 2 below.

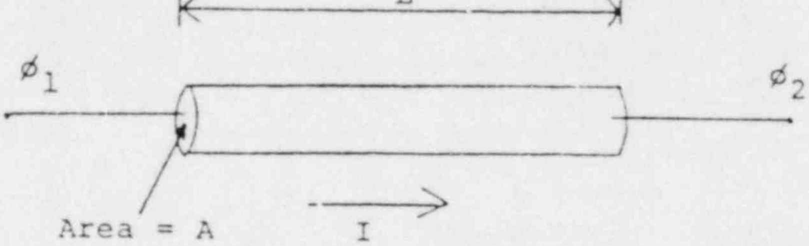


Figure 2. Resistive Material

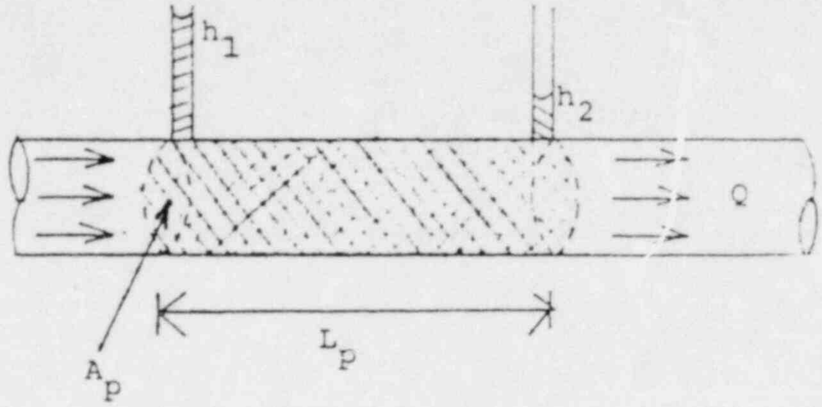
The resistance of the material is directly proportional to its length and inversely proportional to its cross-sectional area. That is:

$$R = \rho \frac{L}{A} \qquad 2.$$

Where the proportionality constant ρ is called the resistivity. The units of ρ may be expressed as ohms-meters^2/meter or ohm-meters. If we apply Ohm's law to the circuit element in Figure 2, we can express the current as

$$I = \frac{A}{\rho} \frac{(\phi_1 - \phi_2)}{L} \qquad 3.$$

We are now ready to illustrate the analogy between Ohm's law and Darcy's law. Consider a sand-filled pipe of length L_p and cross-sectional area A_p as shown in Figure 3.



Sand Filled Pipe

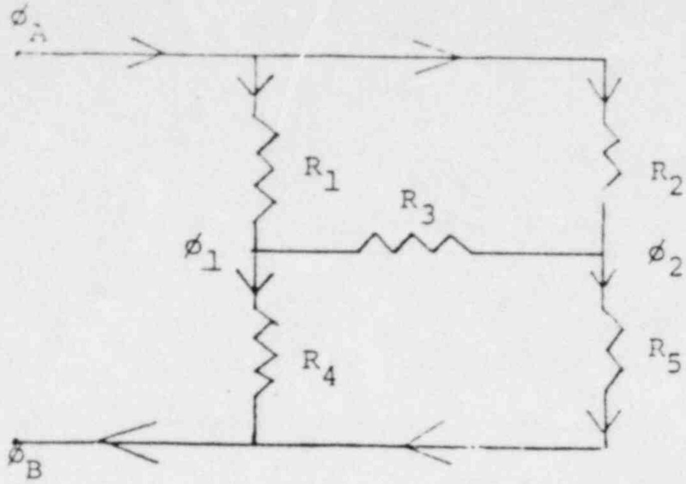
Figure 3.

For this simple case, Darcy's law gives

$$Q = K A_p \frac{h_1 - h_2}{L_p} \qquad 4.$$

where K is the hydraulic conductivity of the sand. Thus (1/K) is analogous to resistivity (ρ), head (h) is analogous to voltage (ϕ) and fluid flow rate (Q) is analogous to current I.

Now suppose one were given the problem of finding the current through each resistor in the circuit of Figure 4.



Arrows indicate direction assigned for positive current flow

Figure 4.

Circuit of Resistors

Assume that ϕ_A, ϕ_B, and R_1 through R_5 are known. Then if ϕ_1 and ϕ_2 can be determined, Ohm's law can be used to find the current through any of the resistors. The unknown voltages ϕ_1 and ϕ_2 can be determined by using Kirchhoff's first rule for electrical networks which states, "At any junction point in a network, the total current arriving at the junction must equal the total current leaving." As current results from the movement of electrical charge, this rule is equivalent to charge conservation. If we define I_j as the current through which resistor R_j, then Kirchhoff's first rule gives

$$I_1 = I_3 + I_4$$

$$I_2 + I_3 = I_5 \qquad 5.$$

Also, Ohm's law gives

$$I_1 = \frac{\phi_A - \phi_1}{R_1} \qquad I_3 = \frac{\phi_1 - \phi_2}{R_3} \qquad I_5 = \frac{\phi_2 - \phi_B}{R_5}$$

$$I_2 = \frac{\phi_A - \phi_2}{R_2} \qquad I_4 = \frac{\phi_1 - \phi_B}{R_4} \qquad 6.$$

If Eqs. 6 are substituted into Eqs. 5, two equations with two unknowns result. These equations can be solved for the unknown voltages ϕ_1 and ϕ_2 and thus the unknown currents I_1 through I_5 can be calculated.

The procedure for calculating unknown currents in a resistance circuit is identical to the procedure used in NWFT/DVM to calculate unknown fluid flow rates.

The analogy between groundwater systems and electrical circuits can be taken considerably further. For instance, the aquifer storage coefficient can be related to capacitance. However, we have adequate material here to understand the flow model in NWFT/DVM.

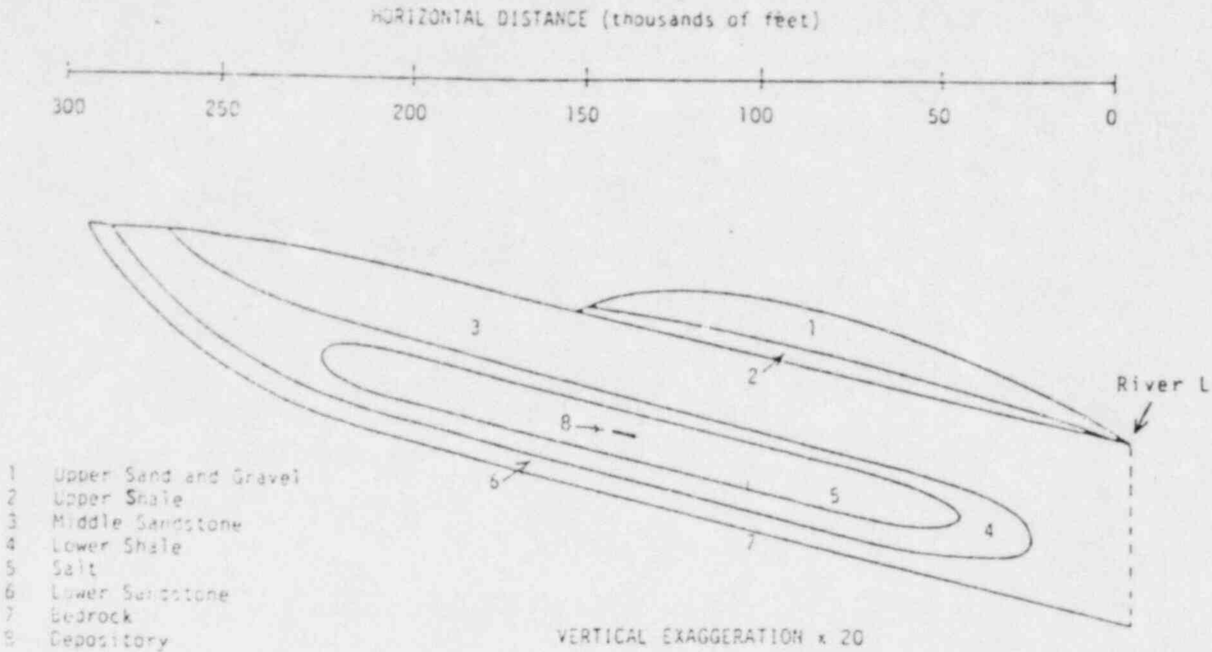
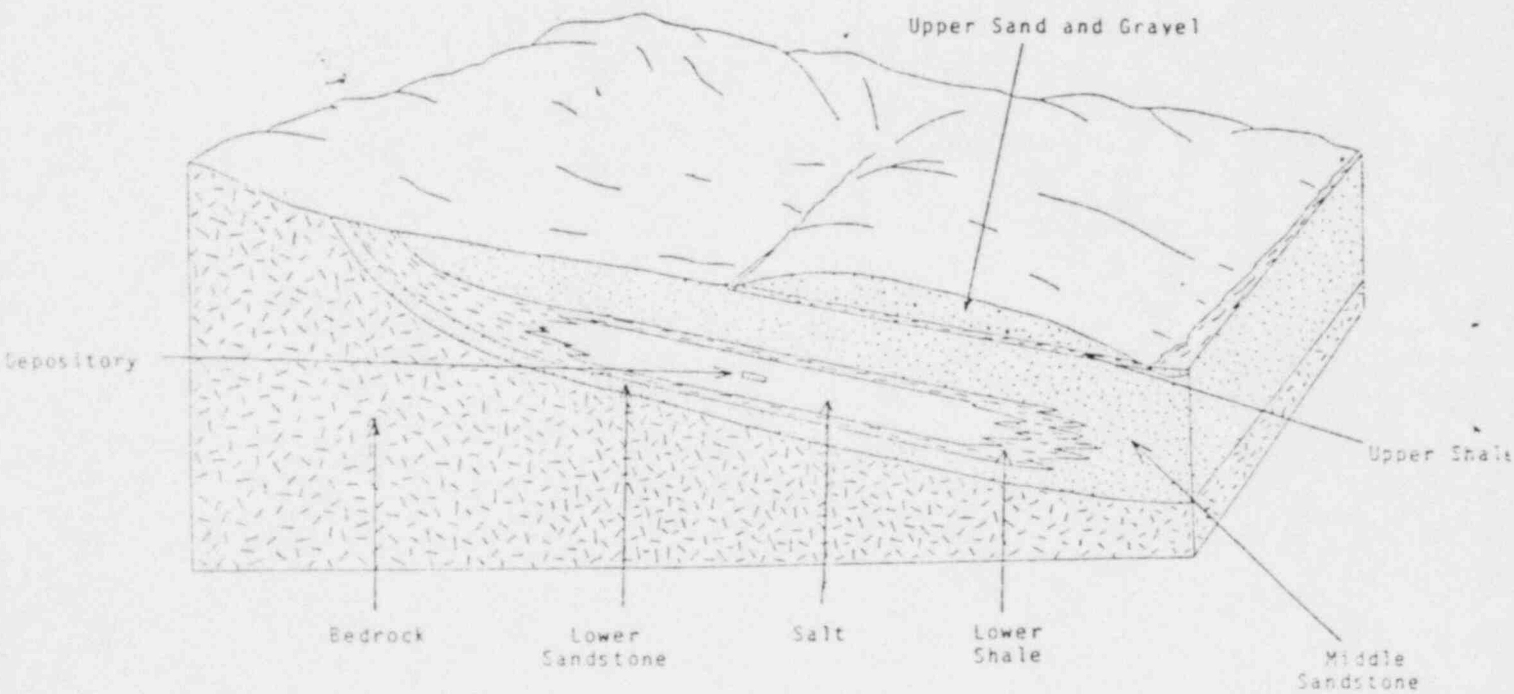


Figure 5. The Reference Site Geology



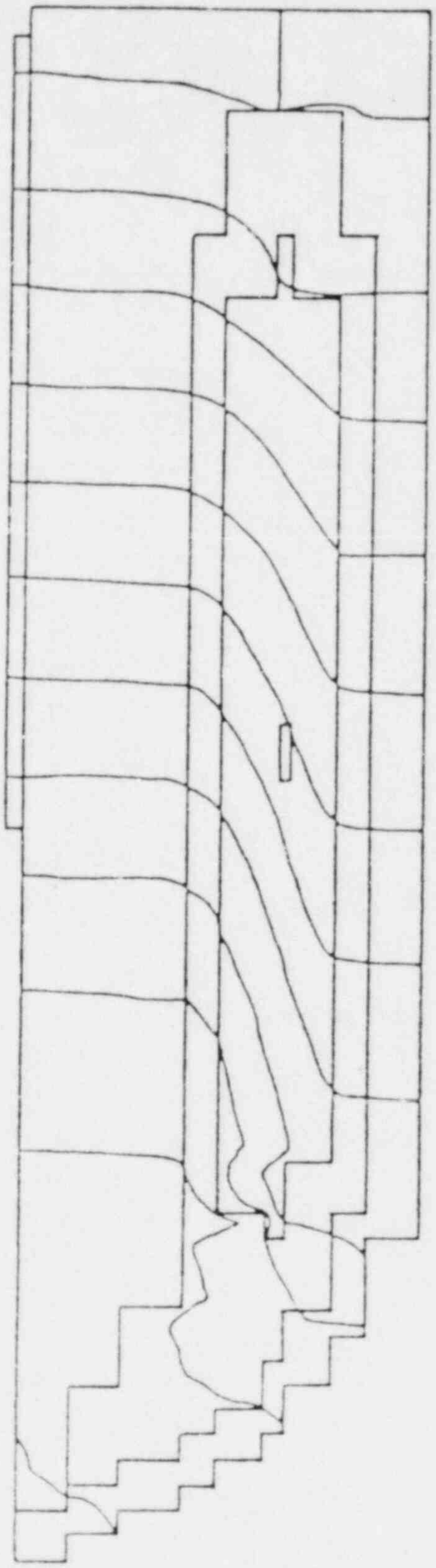


Figure 6. Hydraulic Head Distribution at the Reference Site

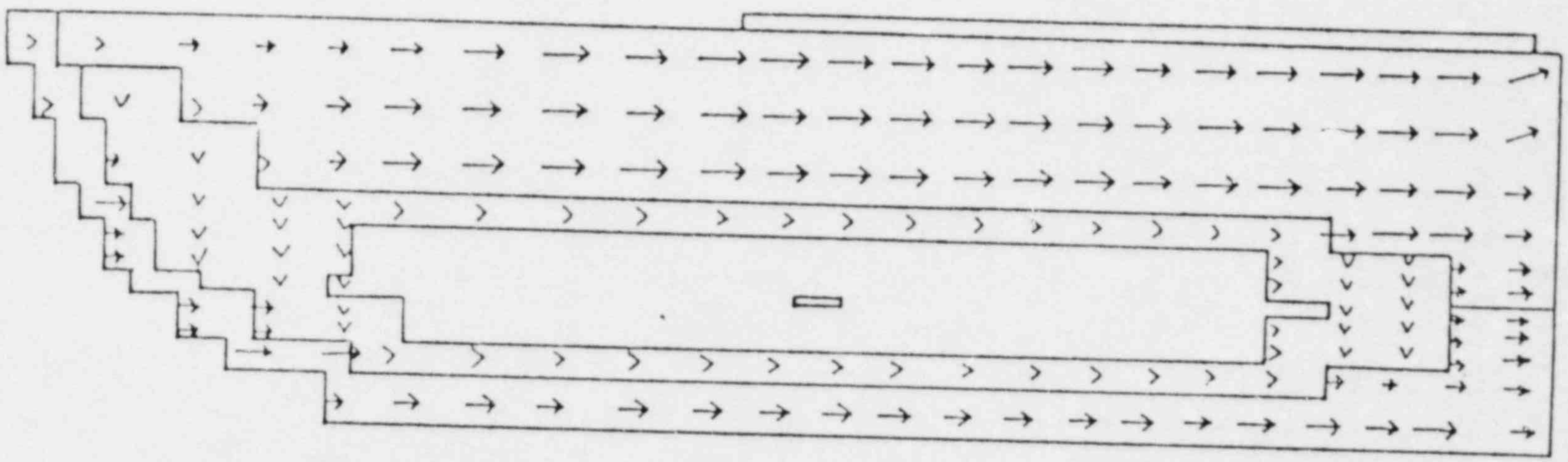


Figure 7. Darcy Velocity Vectors for the Reference Site

The Reference Site Flow System

Groundwater flow calculations for the reference site (Figure 5) have been performed using the SWIFT model.* The hydraulic head distribution, as predicted by SWIFT, is shown in Figure 6. Darcy velocity (or specific discharge) vectors are shown in Figure 7. As the valley in which the reference site is located is assumed to be symmetrical about River L, a no-flow boundary is used under River L. Therefore all the water moving through the middle and lower sandstone aquifers discharges to River L. Except for the near vicinity of River L, fluid flow in the middle and lower sandstone aquifers is essentially one-dimensional. The hydraulic gradient in the vicinity of the depository is downward across the salt and shale layers. However, because of the extremely low hydraulic conductivities assigned to the salt and shale, there is very little fluid flow across these layers.

The NWFT/DVM NETWORK

The network analog used in NWFT/DVM is shown in Figure 8. Legs 1, 2, 3 and 4 are used to represent the middle sandstone aquifer. Legs 5, 6, 7 and 8 represent the lower aquifer and leg

*M. Reeves and R. Cranwell, "User's Manual for the Sandia Waste-Isolation Flow and Transport Model (SWIFT) Release 4.81," NUREG/CR-2324 and SAND81-2516, Sandia National Laboratories, Albuquerque, New Mexico, November 1981.

SWIFT Self-Teaching Curriculum, SAND81-0410, NUREG/CR-1968, March 1982.

15 represents discharge from the lower aquifer to River L. Leg 13 represents the depository and legs 9 through 12 are used to represent various disruptive features which affect the salt and shale layers near the depository. Leg 14 provides some flexibility for simulating the effects of disruptive features down-dip from the depository.

Fluid discharge (ft^3/day) in legs 1 through 15 is given by

$$
\begin{aligned}
Q_1 &= \theta_1 \left[\frac{P_1 - P_4}{\rho_1} + (d_1 - d_4) \right] \\
Q_2 &= \theta_2 \left[\frac{P_4 - P_5}{\rho_2} + (d_4 - d_5) \right] \\
Q_3 &= \theta_3 \left[\frac{P_5 - P_{10}}{\rho_3} + (d_5 - d_{10}) \right] \\
Q_4 &= \theta_4 \left[\frac{P_{10} - P_3}{\rho_4} + (d_{10} - d_3) \right] \\
Q_5 &= \theta_5 \left[\frac{P_2 - P_8}{\rho_5} + (d_2 - d_8) \right] \qquad (7.) \\
Q_6 &= \theta_6 \left[\frac{P_8 - P_9}{\rho_6} + (d_8 - d_9) \right] \\
Q_7 &= \theta_7 \left[\frac{P_9 - P_{11}}{\rho_7} + (d_9 - d_{11}) \right] \\
Q_8 &= \theta_8 \left[\frac{P_{11} - P_{12}}{\rho_8} + (d_{11} - d_{12}) \right] \\
Q_9 &= \theta_9 \left[\frac{P_6 - P_4}{\rho_9} + (d_6 - d_4) \right]
\end{aligned}
$$

$$Q_{10} = \theta_{10} \left[\frac{P_7 - P_5}{\rho_{10}} + (d_7 - d_5) \right]$$

$$Q_{11} = \theta_{11} \left[\frac{P_8 - P_6}{\rho_{11}} + (d_8 - d_6) \right]$$

$$Q_{12} = \theta_{12} \left[\frac{P_9 - P_7}{\rho_{12}} + (d_9 - d_7) \right]$$

$$Q_{13} = \theta_{13} \left[\frac{P_6 - P_7}{\rho_{13}} + (d_6 - d_7) \right]$$

$$Q_{14} = \theta_{14} \left[\frac{P_{11} - P_{10}}{\rho_{14}} + (d_{11} - d_{10}) \right]$$

$$Q_{15} = \theta_{15} \left[\frac{P_{12} - P_3}{\rho_{15}} + (d_{12} - d_3) \right]$$

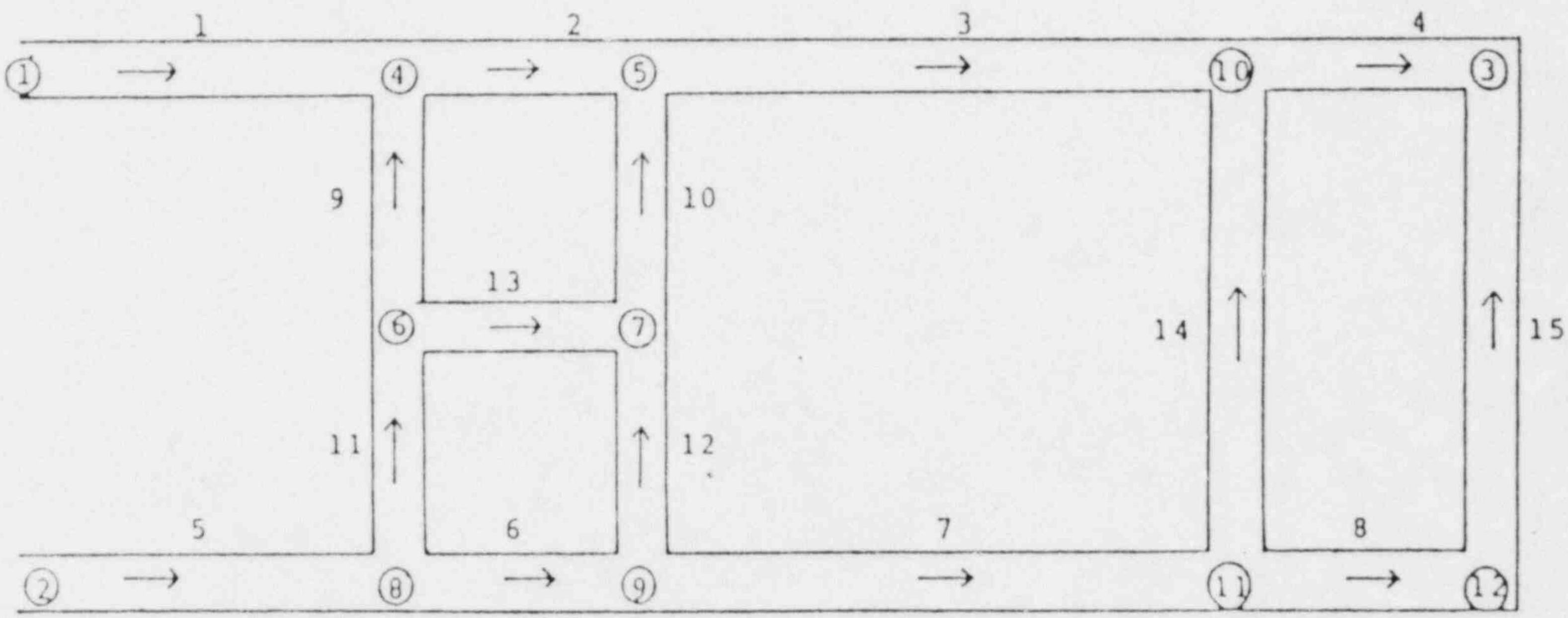


Figure 8. The NWFT/DVM Flow Network. Arrows Indicate Assumed Direction of Positive Flow. Legs are Numbered as Indicated. Junction Numbers are circled.

where $\theta_i = \frac{A_i K_i}{L_i}$

K_i = hyraulic conductivity in leg i (ft/day)

A_i = cross-sectional area of leg i (ft^2)

L_i = length of leg i (ft)

ρ_i = fluid density in leg i (lb/ft^3)

P_j = fluid pressure at junction j (lb/ft^2)

d_j = elevation above datum of junction j (ft)

The pressure boundary conditions (P_1, P_2, P_3) are required as input as are all junction elevations. All leg properties (area, length, porosity and hydraulic conductivity) are provided by the user as input. Input values of hydraulic conductivity are assumed to be fresh water values. The brine concentration in each leg (required as input) is used to determine fluid density and viscosity in each leg using a simplified model described below. These values of fluid density and viscosity are then used to modify the input values of hydraulic conductivity to account for the presence of brine.

Fluid Density and Viscosity

Water density and viscosity are functions of temperature, pressure and brine concentration. However, for present purposes, the dependence of water density and viscosity on pressure are negligible. Furthermore, a thermal model has not been included as NWFT/DVM is intended for use as a far field model and thermal effects from the radioactive waste are confined to a relatively small region about the depository. Thus, in NWFT/DVM, water density and viscosity are modelled as functions of brine concentration only.

Water density is modelled as a linear function of brine concentration. That is

$$\rho(C) = \rho_0 + C\ (\rho_1 - \rho_0) \qquad 8.$$

where

C = dimensionless brine concentration; i.e., C = 0 for fresh water and C = 1 for saturated brine

ρ_0 = density of fresh water at the reference temperature ($\rho_0 \approx 62.3$ lb/ft^3 at 68°F)

ρ_1 = density of saturated brine at the reference temperature ($\rho_1 \approx 74.02$ lb/ft^3 at 68°F)

The dependence of viscosity on concentration of dissolved solids can be approximated as

$$\mu(T,C) = \mu(T,0)\ [1.0 + 0.005\sqrt{\sum_{i=1}^{N} c_i} + \sum_{i=1}^{N} A_i c_i] \qquad 9.$$

where

c_i = concentration of dissolved ion (i) in moles/liter

A_i = temperature dependent coefficient

$\mu(T,0)$ = viscosity of fresh water at temperature T

N = number of dissolved species

In nature, solutions containing more than 10 or 15 moles/liter of dissolved ions are unlikely if not unknown. Therefore, the square root term in Eq. (9) is neglected. Assuming $NaC\ell$ is the primary dissolved mineral, the N=2 and the dissolved species are Na^+ and $C\ell^-$. For these ions, the coefficients (A) are approximately independent of temperature.

$$A(C\ell^-) \approx 0$$

$$A(Na^+) \approx 0.08$$

Then

$$\mu(T,C) = \mu(T,0)\ [1.0 + 0.08\ c(Na^+)] \qquad 10.$$

We take T = 68°F as a reference temperature and drop the temperature dependence in Eq. 10. Then

$$\mu(C) = \mu(0) + [1.0 + 0.08\ c\ (Na^+)]$$

$$c(Na^+) = W\left(\frac{\text{lb salt}}{\text{lb sol.}}\right) \cdot C \cdot \rho\left(\frac{\text{lb salt}}{\text{ft}^3\ \text{sol}}\right) \cdot 454\left(\frac{\text{gm}}{\text{lb}}\right) \cdot \left(\frac{1}{2.83 \times 10^4}\right)\left(\frac{\text{ft}^3}{\text{cm}^3}\right) \cdot 1000\left(\frac{\text{cm}^3}{\ell}\right) \cdot \left(\frac{1}{58.443}\right)\left(\frac{\text{moles NaC}\ell}{\text{gm}}\right) \qquad 11.$$

Where W = weight fraction of salt in saturated brine.

C = dimensionless brine concentration

$\rho = \rho(C)$ = density of brine at concentration C

In Eq. (11), we used the fact that $c(Na^+)$ is equal to the moles of NaCℓ per liter of solution.

Then

$$c(Na^+) = 0.274\ WC\rho$$

$$\text{and } \mu(C) = \mu(0)\ [1.0 + 0.0219\ WC\rho] \qquad 12.$$

Well Capability

There is a feature in NWFT/DVM that allows the user to place a system of withdrawal wells on any network leg. The wells remove a fraction of the aquifer flow. However, it is assumed that the wells do not significantly alter the fluid flow. Further, it is assumed that the lateral extent of the well field is greater than that of the contaminant plume. This avoids the problem of calculating lateral spreading of the contaminant plume.

The NWFT/DVM model automatically shortens the migration path to the location of the wells. It then assumes that the fraction of radionuclides taken up by the wells is the same as the fraction of aquifer flow withdrawn. Thus, the radionuclide discharge rates are reduced by this fraction. The dissolved material not withdrawn will continue migrating to River L. However, a separate NWFT/DVM calculation must be performed to obtain discharge at River L.

Overall NWFT/DVM Logic

The NWFT/DVM model is equipped to execute multiple data sets and to replace entries from the input file with values from an exterior file. Use of multiple data sets is demonstrated in the sample problems below. Use of exterior files is helpful for statistical analyses. The logical sequence of the model is presented on the following flow chart, Figure 9.

Input is read by routine FLOWIN. The normal end of execution is attained when FLOWIN attempts to read beyond the last data set.

If there is an exterior file of information to be used, it is said to contain input vectors. That is, each input vector has as its elements values to replace certain entries on the input file. The reading of the exterior file and the replacement of input values is done in routine GETRV.

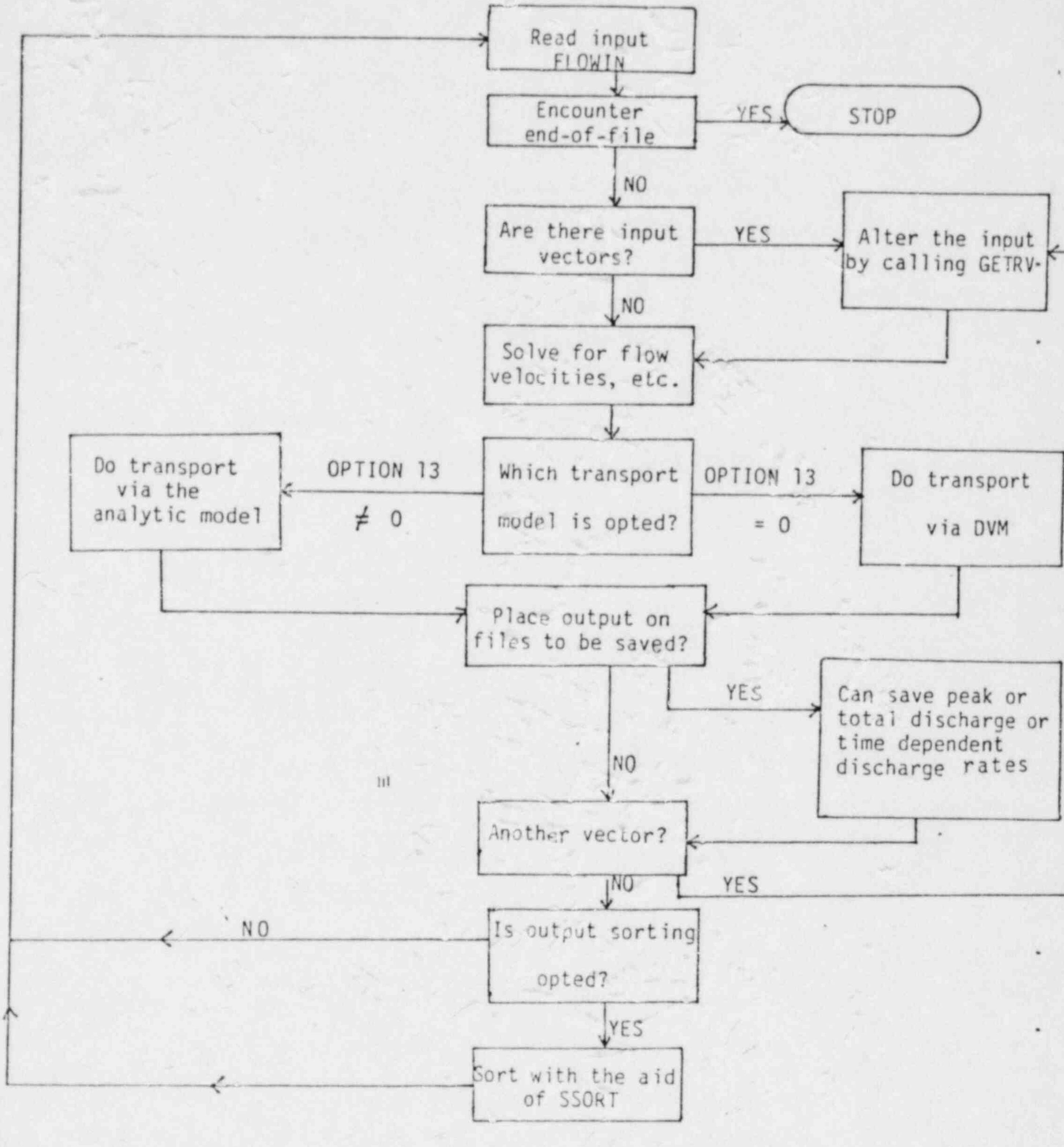


Figure 9. Overall Structure of NWFT/DVM - ANAMOD

With all input now stored in the appropriate arrays, the network flow system is solved. Resulting migration path and velocity information are used as input to either the analytic or DVM transport models. Output from either model may be written to a separate file. The possible forms of output are time-dependent discharge rates, peak discharge rates, or total discharge.

The model continues to loop over all input vectors. At completion, peak or integrated discharges may be sorted into ascending order over all vectors for each species. If input vectors are not used then sorting is not performed.

At this point, FLOWIN is again accessed. If there is no further input, data execution stops. Otherwise, new input is selectively read (see the INP array description in the User's Manual)*. Flow and transport are calculated as before.

Flow Model Subroutines

A flow chart for the network flow model is now presented (Figure 10). Subroutines called from the main program, ANAMOD, are within the dashed lines. Brief descriptions of each routine are given below. Further information can be found in the User's Manual.

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*Campbell, J.E., Longsine, D. E., and Cranwell, R. M.; Risk Methodology for Geological Disposal of Radioactive Waste: The NWFT/DVM Computer Code User's Manual, NUREG/CR-2081 and SAND81-0886, Sandia National Laboratories, Albuquerque, N.M., 1981.

Subroutine USEINP determines permeability, viscosity, fluid density, rock density, and transmissivity of each leg. It calculates retardation factors for each isotope in each leg of the migration path. It also finds decay constants and ages the input inventory to release time. For non-zero release time, BRANCH is utilized to set up decay chain information. USEINP has several optional print statements and optionally calls routine SCHEMA. SCHEMA draws the network schematic.

Subroutine COEFF sets up the transmissivity array and the constant vector used for solving the flow equations. LEQTIF is a linear equations solving routine which calculates the unknown pressures. Note the LEQTIF is found in IMSL* (Mathematical/Statistical Library of Computer Codes). Thus, it is necessary to attach this library for NWFT/DVM execution.

Subroutine PATHLEN calculates fluid flow rates in each leg. Darcy and interstitial velocities can then be found. The call to CHKPATH is to ensure that the migration path input by the user conforms to the calculated flow and velocity. Migration path length and average fluid and retarded velocities are then found. Finally PATHLEN optionally prints flow, velocity, and path information.

Sample Problem 1 can now be addressed using the information presented thus far.

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*International Mathematical and Statistical Libraries, IMSL Library Reference Manual, Edition 8, Vol. 2, 1980.

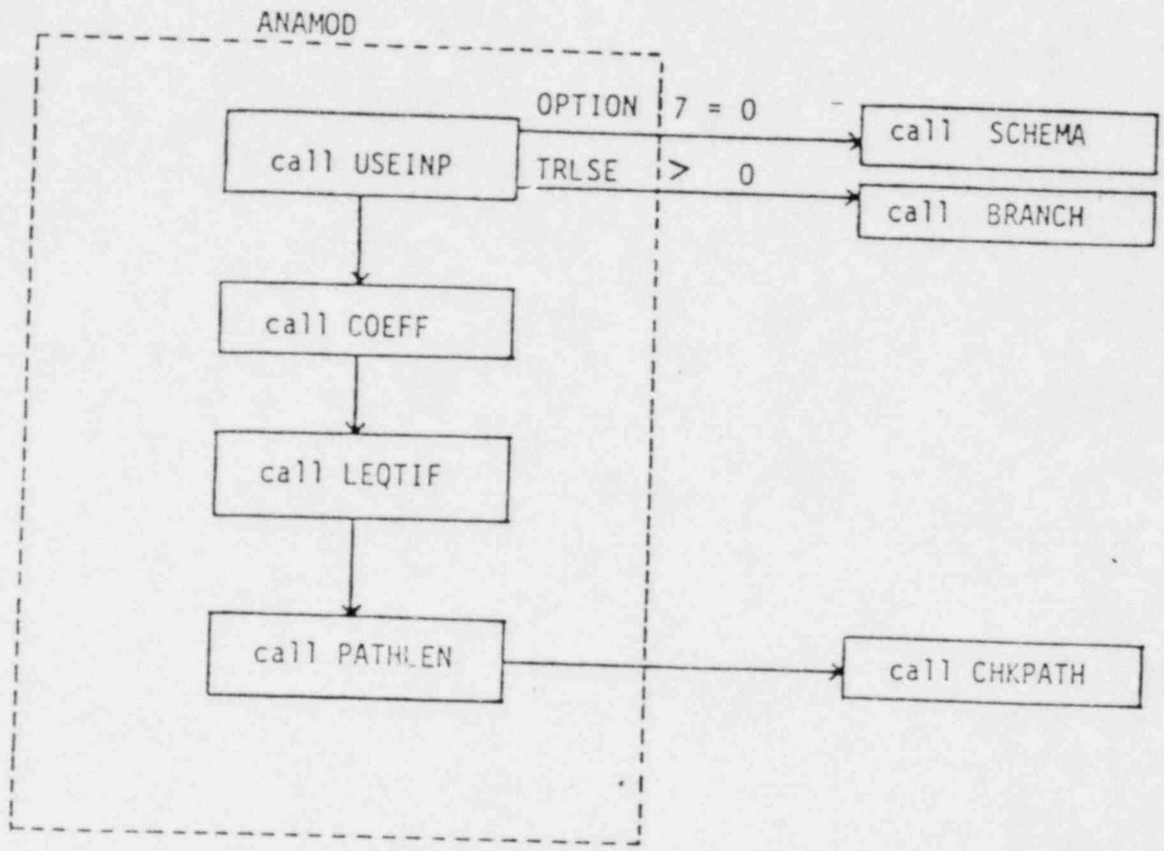

Figure 10. Flow Model Flow Chart

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III Analytic Transport Option

The analytic solutions to the one-dimensional transport equation which provided the transport capability in NWFT have been retained as an option in NWFT/DVM. Use of the analytic transport option is limited to problems involving chains of no more than three radionuclides which have the same distribution coefficient. As these solutions have been derived for a decaying band release, they are suitable for a leach-limited source with a constant leach rate.

The migration of a three-member chain in a one dimensional system is described by the following equations

$$R_1 \frac{\partial N_1}{\partial t} = D \frac{\partial^2 N_1}{\partial x^2} - V \frac{\partial N_1}{\partial x} - R_1 \lambda_1 N_1 \quad 13.$$

$$R_2 \frac{\partial N_2}{\partial t} = D \frac{\partial^2 N_2}{\partial x^2} - V \frac{\partial N_2}{\partial x} - R_2 \lambda_2 N_2 + R_1 \lambda_1 N_1 \quad 14.$$

$$R_3 \frac{\partial N_3}{\partial t} = D \frac{\partial^2 N_3}{\partial x^2} - V \frac{\partial N_3}{\partial x} - R_3 \lambda_3 N_3 + R_2 \lambda_2 N_2 \quad 15.$$

I II III IV V

where R_i = retardation factor for species i

N_i = concentration in solution of species i

$D = |v|\alpha$ = dispersion coefficient

α = dispersivity

λ_i = decay constant for species i

Referring to Eq. 15, the terms in the equation can be interpreted as follows:

I. $R_3 \frac{\partial N_3}{\partial t}$ = time rate of change in both the sorbed and dissolved concentration of species 3.

II. $D \frac{\partial^2 N_3}{\partial x^2}$ = rate of change in species 3 concentration due to dispersion - only affects the dissolved component.

III. $V \frac{\partial N_3}{\partial x}$ = rate of change in species 3 concentration due to convection - only affects the dissolved component.

IV. $R_3 \lambda_3 N_3$ = rate of change in species 3 concentration due to radioactive decay - affects both the sorbed and dissolved components.

V. $R_2 \lambda_2 N_2$ = rate of change in species 3 concentration due to production from species 2 - affects both the sorbed and dissolved components of species 2.

For the case $R_1 = R_2 = R_3$, the time-dependent discharge rates predicted by Eqs. 13, 14, and 15 are

$$DR_1(t) = \frac{N_1(0)}{2\tau} e^{-\lambda_1 t} \left[(U(t)-U(t-\tau)H(t-\tau))\right] \quad 16.$$

$$DR_2(t) = \left[\frac{N_2(0)}{2\tau} e^{-\lambda_2 t} + \frac{N_1(0)}{2\tau}\left(\frac{\lambda_1}{\lambda_2-\lambda_1}\right)\left(e^{-\lambda_1 t} - e^{-\lambda_2 t}\right)\right] \quad 17.$$

$$\left[[U(t) - U(t-\tau)H(t-\tau)]\right]$$

$$DR_3(t) = \left[\frac{N_3(0)}{2\tau} e^{-\lambda_3 t} + \frac{N_2(0)}{2\tau}\left(\frac{\lambda_2}{\lambda_3-\lambda_2}\right)\left(e^{-\lambda_2 t} - e^{-\lambda_3 t}\right) + \right. \quad 18.$$

$$\frac{N_1(0)}{2\tau} \lambda_1 \lambda_2 \frac{e^{-\lambda_1 t}}{(\lambda_2-\lambda_1)(\lambda_3-\lambda_1)} + \frac{e^{-\lambda_2 t}}{(\lambda_1-\lambda_2)(\lambda_3-\lambda_2)} +$$

$$\left.\frac{e^{-\lambda_3 t}}{(\lambda_1-\lambda_3)(\lambda_2-\lambda_3)}\right] \cdot \left[[U(t)-U(t-\tau)H(t-\tau)]\right] .$$

where

τ = leach time for a constant leach rate source

$H(x) = 0 \quad x < 0$

$H(x) = 1 \quad x \geq 0$

and the function $U(t)$ is given by

$$U(t) = \text{erfc}\left[\frac{L_p - \frac{V}{R}t}{\sqrt{4\alpha Vt/R}}\right] + \exp\left[\frac{L_p}{\alpha}\right] \text{erfc}\left[\frac{L_p + \frac{V}{R}t}{\sqrt{4\alpha Vt/R}}\right] \quad 19.$$

erfc = complementary error function

L_p = total migration path length

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Notebook Divider Should Read: ANALYTIC TRANSPORT OPTION

Time Steps for the Analytic Transport Model

Discharge rates from the analytic transport model are given at selected times between release time, T_R, and the problem upper bound time, TUB. In subroutine METHOD a starting time, TSTART, and an ending time, TEND, are found. The time interval [TSTART, TEND] is designed to include all times between T_R and TUB for which there is significant discharge. A time step, DT, is then defined by

$$DT = (TEND-TSTART)/200.$$

Output is given at the selected times

$$t_i = TSTART + i \quad DT, \; i = o, \ldots, 200.$$

This selection of discharge times is motivated by two considerations. First, 200 points are generally adequate to resolve a discharge curve. Second, unneeded zero-discharge information is avoided.

To determine TSTART and TEND, first refer to Figure 11. For a non-decaying species and a constant, leach-controlled source rate, the discharge curve has the shape depicted. The leading and trailing portions take the shape of an error function for which the underlying Gaussian distribution has the following standard deviation.

$$\sigma_T = \sqrt{2 \alpha X} / \overline{V}_r,$$

where

α = dispersivity in ft

x = path length in ft

$\bar{v}_r$ = average velocity in ft/yr The time $T_m = x/\bar{v}_r$ is the average migration time and τ is the leach duration.

Four standard deviations in time are taken to find TSTART and TEND. That is,

$$TSTART = \max \left\{ T_m + T_R - 4\sigma_T \ , \ T_R \right\}$$

$$TEND = \min \left\{ T_m + T_R + \tau + 4\sigma_T \ , \ TUB \right\}$$

Clearly radioactive decay can distort the discharge curve of Figure 11 but TSTART and TEND remain as adequate bounds.

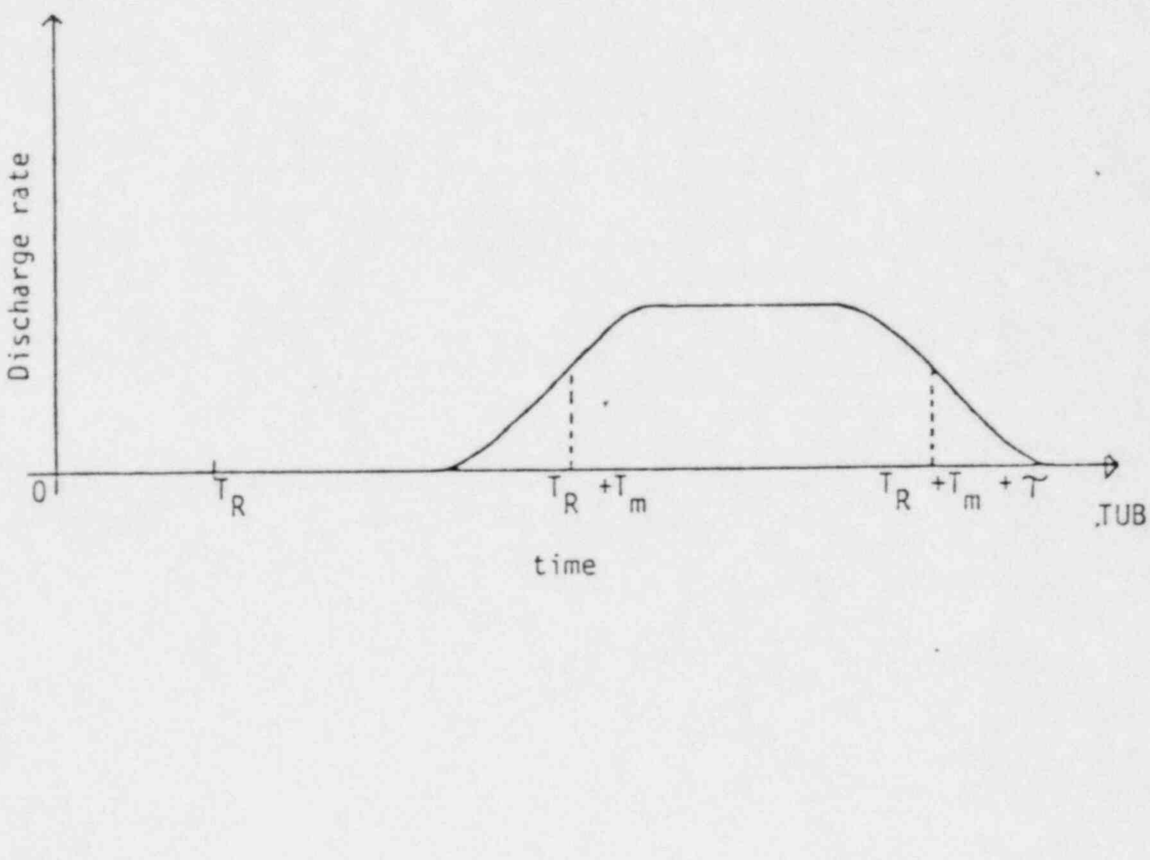


Figure 11, Discharge curve for a non-decaying species

Analytic Transport Model Subroutines

The calling sequence for the analytic transport model is depicted in the next flow chart (Figure 12). After the flow calculations, subroutine METHOD is accessed from ANAMOD. In METHOD, a nonzero value for option 13 indicates that the analytical solution will be used. METHOD sets up the starting, stopping, and increment times as previously discussed.

The remainder of the calculations are performed by BAND and GIT. Subroutine BAND loops over time finding and applying decay and production factors to values found by GIT. Function GIT returns U(t) for a given value of t. Subroutine TPPRT writes time and discharge rates to output, an external file, or both.

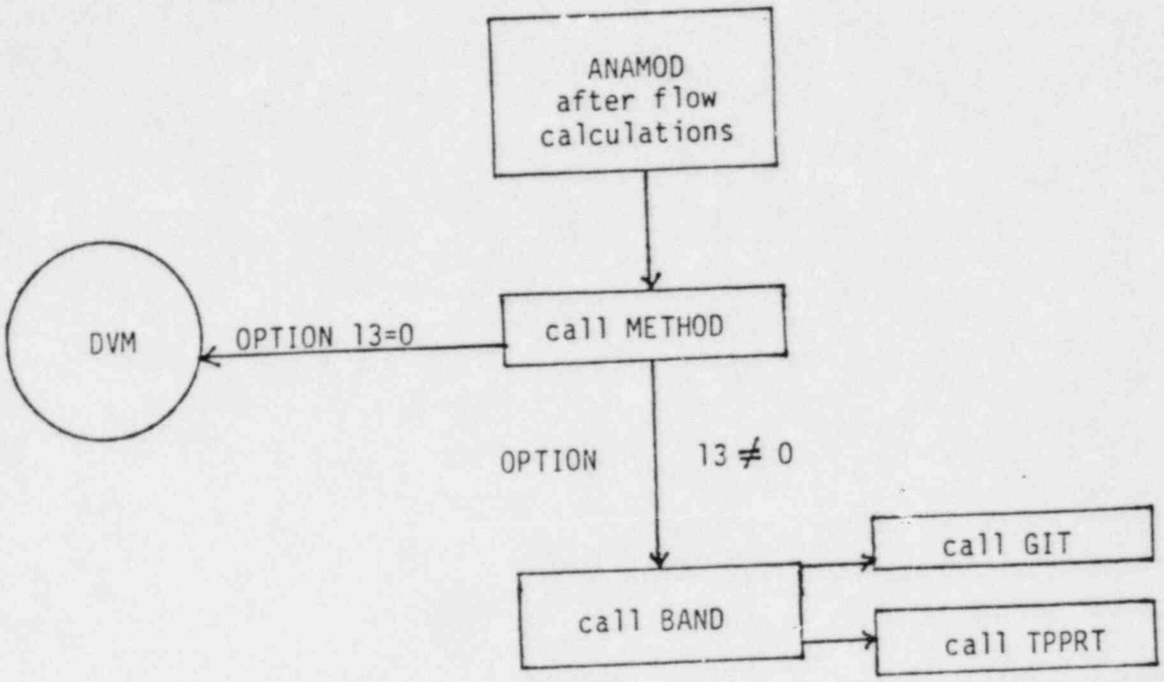


Figure 12. Transport Model Flow Chart

DVM / STC

New Right Hand Page

Notebook Divider Should Read: DVM TRANSPORT OPTION

Sample Problem 2 can be attempted with the information presented so far.

IV. The DVM Transport Option

To examine the DVM concept, consider the migration in one dimension of a non-decaying, non-retarded contaminant. The governing equation is

$$\frac{\partial N}{\partial t} = D \frac{\partial^2 N}{\partial x^2} - \bar{v} \frac{\partial N}{\partial x} + S \qquad 20.$$

For an instantaneous, unit point source

(i.e., $S(x,t) = \delta(x-x') \ \delta(t-t')$).

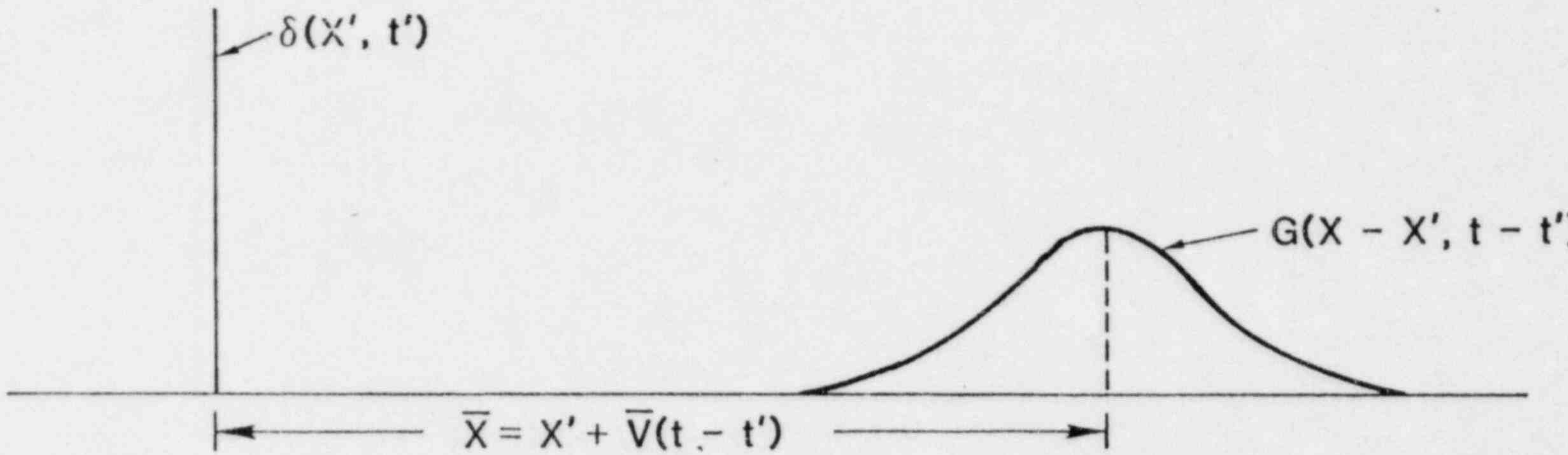
the solution to Eq. (20) is

$$G(x-x',t-t') = \frac{1}{\sqrt{2\pi}\ \sigma_x} \exp^{-}\left\{\frac{[(x-x') - \bar{v}(t-t')]^2}{2\ \sigma_x^2}\right\} \qquad 21.$$

where

$$\sigma_x = \sqrt{2D(t-t')}$$

This solution is illustrated in Figure 13. The function $G(x-x', t-t')$ is known as the Green's function.



$$G(X - X', t - t) = \frac{1}{\sqrt{2\pi}}\,\sigma_X \quad \exp - \left\{ \frac{\left|(X - X') - \bar{V}(t - t')\right|^2}{2\sigma_X{}^2} \right\}$$

Figure 13. Propagation of an Instantaneous, Point Source From t' to t

Equation (20) can be solved for an instantaneous distributed source by considering it to be a collection of point sources. This idea is illustrated in Figure 14. Let the total source be S_o. Then the source strength is defined as

$$S(x',t') = \left(\frac{S_o}{b-a}\right) \delta(t''-t') \quad a \leq x' \leq b$$

$$S(x',t') = 0 \qquad x' < a \ , \ x' > b$$

Thus the contribution from $\Delta x'$ at x_i is

$$\Delta C \approx \frac{1}{\sqrt{2\pi}\,\sigma_x} \frac{S_o\, \delta\,(t'' - t')\,\Delta x'}{(b-a)} \exp\left\{\frac{-\,[(x-x_i') - \bar{v}(t-t'')]^2}{2\,\sigma_x^2}\right\}$$

Summing over the distributed source (and integrating over source time, t"),

$$C(x,t) \approx \sum_{i=1}^{N} \frac{S_o\ \Delta x'}{b-a} \frac{1}{\sqrt{2\pi}\,\sigma_x} \exp\left\{\frac{-[(x-x_i') - \bar{v}(t-t')]^2}{2\,\sigma_x^2}\right\} \qquad 22.$$

where $N = \dfrac{b-a}{\Delta x'}$

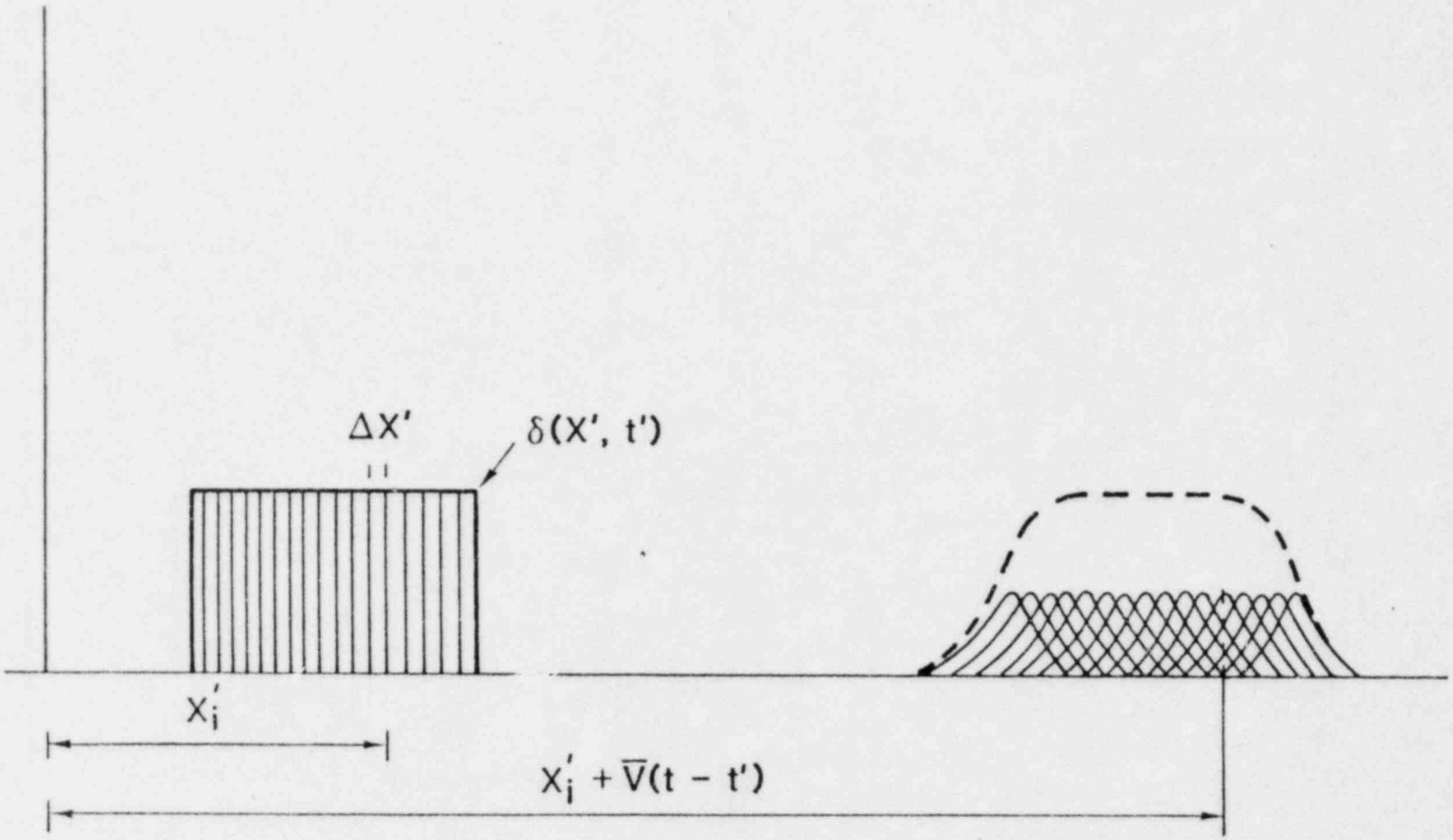


Figure 14. Propagation of an Instantaneous, Distributed Source from t' to t.

In the limit as $\Delta x'$ approaches o, Eq. (22) becomes

$$C(x,t) = \frac{S_o}{(b-a)} \frac{1}{\sqrt{2\pi}\sigma_x} \int_a^b \exp \left\{ \frac{-[(x-x') - \bar{v}(t-t')]^2}{2\sigma_x^2} \right\} dx' \qquad 23.$$

However, to make the transition from an analytical treatment to DVM, we are more interested in Eq. (22) which indicates that the concentration (or density) of contaminant at x at time t can be obtained by summing contributions from the source region at some earlier time t'.

Consider the gridded, one-dimensional system shown in Figure 15 which illustrates the transport of a "point" source in grid block j from time t' to time t. Notice that we have changed notation from contaminant concentration C to density ρ to be consistent with the NWFT/DVM user manual. In this new notation, which will be used for the remainder of the discussion on DVM, $\rho(i,t)$ refers to the particle density in grid block i at time t.

In analogy to Eq. (22), we now seek to develop the following relationship for application of DVM:

$$\rho(i,t) = \sum_{j=1}^{n_s} B(i,j)\, S(j,t') \qquad t' < t \qquad 24.$$

where n_s = number of source grid blocks.

Define $\Delta t = t - t'$

Now the contaminant density $\rho(j,t')$ in any grid block j at time t' is treated as a source in determining the density $\rho(i,t'+\Delta t)$, $i = 1, N_x$. Thus, for transport of contaminant from time t' to $t' + \Delta t$, Eq. (24) becomes

$$\rho(i,t' + \Delta t) = \sum_{j=1}^{N_x} B(i,j)\ \rho(j,t'), \qquad i=1,N_x \qquad 25.$$

Where N_x = total number of grid blocks

Thus the problem of contaminant transport using DVM is primarily a problem of determining the matrix (i.e., Green's function) B(i,j).

Before proceeding with development of the B matrix, it is useful to speculate on some of its characteristics. First, note from Eqs. (21), (22) and (23) that the Green's function depends on x-x' and t-t'. Thus, although we have written

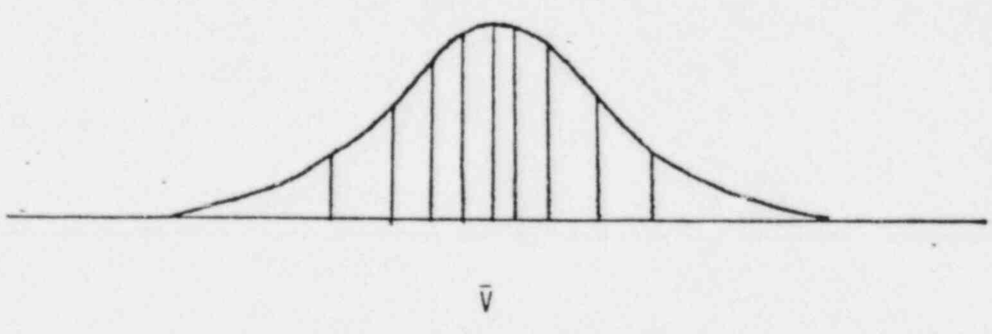
$$B = B(i,j)$$

it might be more appropriate to write

$$B = B(i-j, \Delta t) \quad 26.$$

Thus, if we designate $\rho(j,t')$ in Eq. (25) as the density in source block j and $\rho(i,t' + \Delta t)$ as the density in receiver block i, Eq. (26) implies that the corresponding entry in the B matrix depends only on Δt and the distance (or number of grid blocks) between the source and receiver blocks. Note also that the term B(i,j) can be considered the fraction of the contaminant in block j at time t' that will be found in block i at $t' + \Delta t$.

We now turn to the problem of determining the B matrix. Figure 15 illustrates the transport of a "point" source (i.e., the material in a single grid block) from time t' to t' + Δt. Figure 15 should be compared to Figure 13 which illustrates the Gaussian form at time t which results from a point source at t'. Thus, the immediate problem is to achieve an approximation at a Gaussian distribution in the gridded system shown in Figure 15. This is accomplished by assigning the dissolved contaminant a distribution of velocities. Intuitively, one expects that a Gaussian velocity distribution would be required to recreate a Gaussian spatial distribution. This is shown to be the case in the NWFT/DVM user manual. The velocity distribution is divided into N_v increments of equal probability as illustrated in Figure 16.



Velocity Distribution

Figure 16.

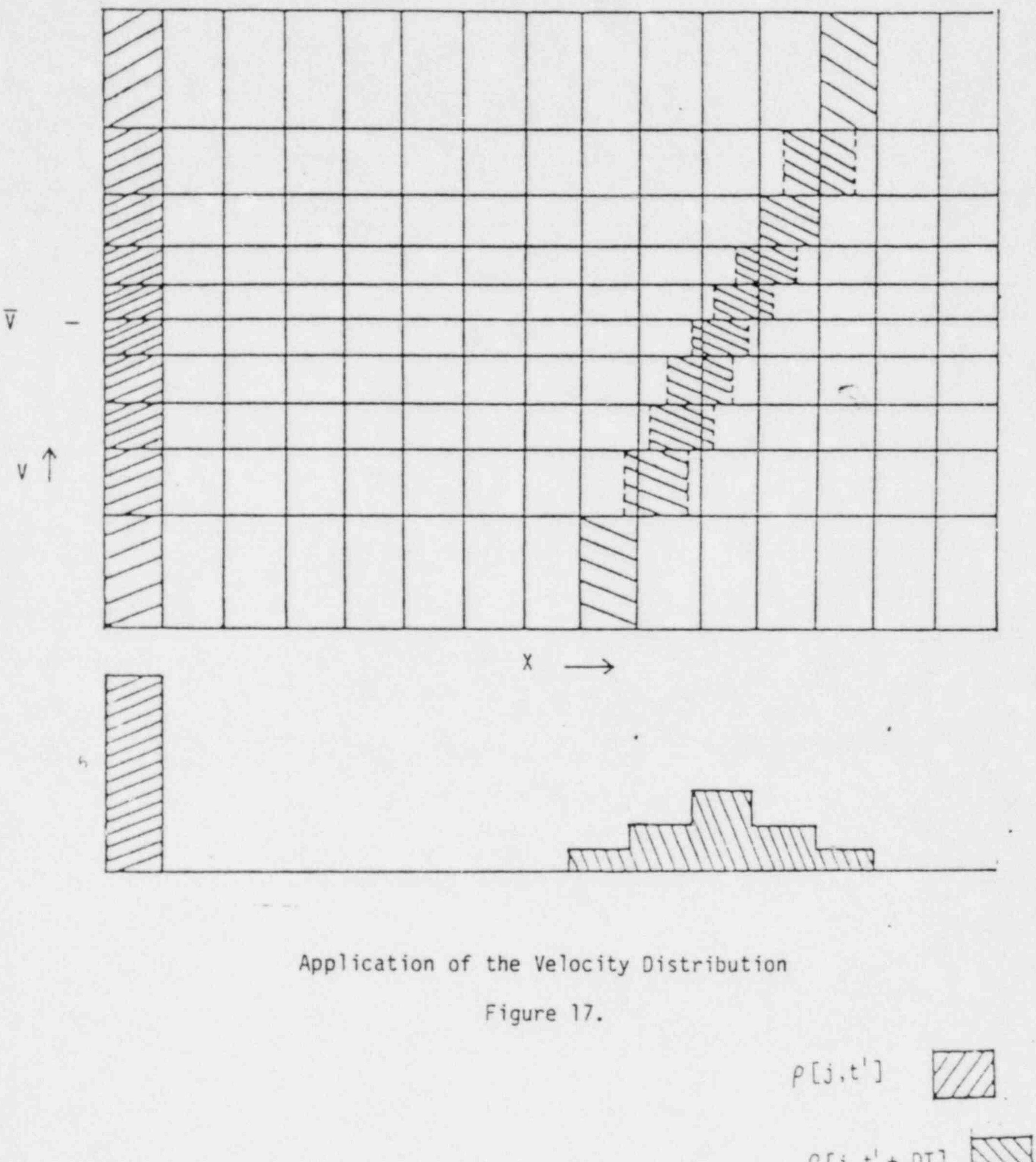
The form of the velocity distribution shown in Figure 16 is

$$G(v, \Delta t) = \frac{1}{\sqrt{2\pi}\,\sigma_v} \exp - \left\{ \frac{(v-\bar{v})^2}{2\sigma_v^{\,2}} \right\} \qquad 27.$$

where $\sigma_v = \sigma_x / \Delta t = \sqrt{2D\,\Delta t} \;/ \Delta t = \sqrt{2D/\Delta t}$

Application of the velocity distribution is illustrated in Figure 17. As the N_v velocity intervals are selected to have equal probability, each interval is assigned $1/N_v$ of the source block contaminant. In Figures 16 and 17, ten velocity intervals are used so that 1/10 of the contaminant in the source grid block is assigned to each velocity interval. The contaminant packet in a given velocity interval is assigned the median velocity for that interval. The transport of contaminant from t' to t' + Δt is illustrated in Figure 17. The resulting spatial distribution of dissolved contaminant is obtained by summing over velocities.

Now consider Figure 18 which shows the transport of contaminant in a single velocity interval. Looking at velocity interval j, we see that there are, in general, two contributions to receiver block i. One is a packet of particles coming from donor block i-k and the other is a packet coming from donor block i-k-1. As is also indicated in Figure 18, there is generally only partial overlap of the propagated block contents with receiver block i.



Application of the Velocity Distribution

Figure 17.

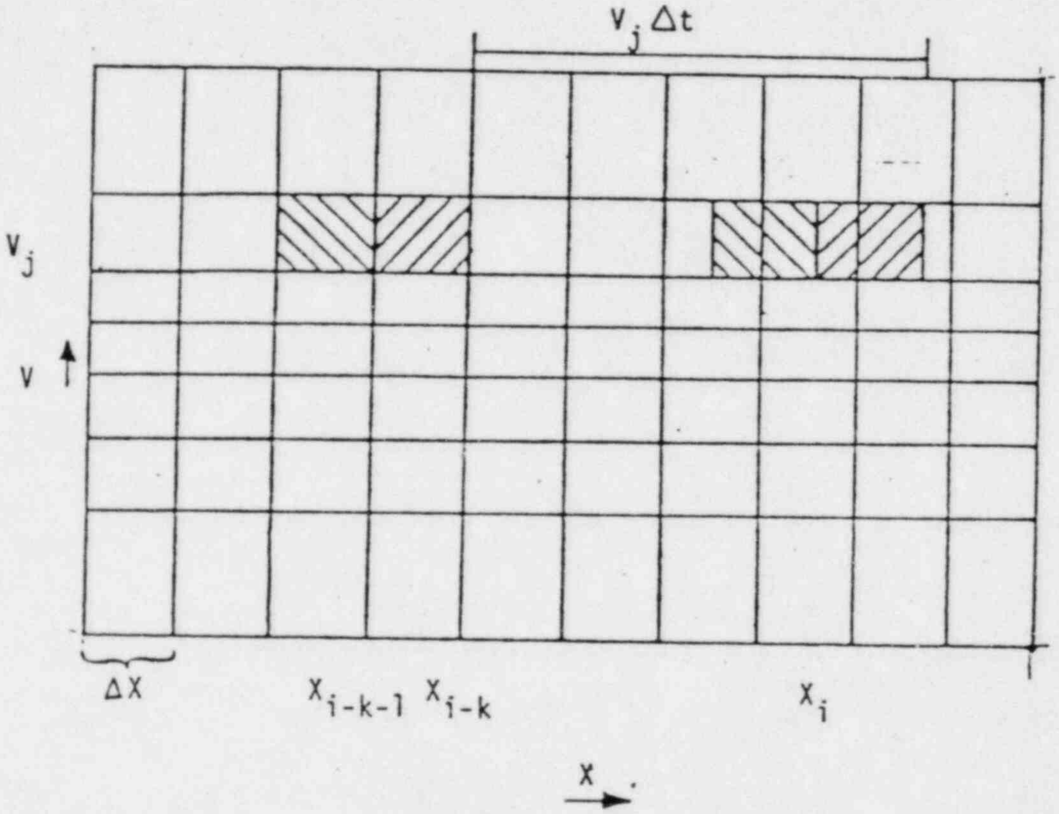


Figure 18. Discretized Velocity - Space Domain

The donor block index is $i - k_j$

where

$$k_j = [[V_j \, \Delta t / \Delta x]], \qquad 28.$$

$$[[\ z\ ]] = \text{greatest integer} \leq z$$

;

and V_j is the velocity assigned to interval j. The fractional overlap of velocity packet j in grid block $i - k_j$ with receiver block i is

$$M(j) = 1 - (V_j \ \Delta t / \ \Delta x - k_j) \qquad 29.$$

and the fractional overlap from block $i-k_j-1$ is $1 - M(j)$. Thus the particle density in grid block i at time $t' + \Delta t$ is

$$\rho(i,t' + \Delta t) = \frac{1}{N_v} \sum_{j=1}^{N_v} \Big\{ M(j)\ \rho\ (i-k_j,t') + [1-M(j)]\ \rho\ (i-k_j-1,t') \Big\} \qquad 30.$$

If the contaminant is radioactive, then there is a reduction in concentration by the amount

$$\mathcal{D} = C\ e^{-\lambda \Delta t} \qquad 31.$$

where λ = decay constant

Thus for a single radionuclide,

$$\rho(i,t' + \Delta t) = \frac{\mathcal{D}}{N_v}\sum_{j=1}^{N_v} \left\{M(j)\,\rho(i-K_j,t')+[1-M(j)]\rho(i-k_j-1,t')\right\} \quad 32.$$

For a chain of radionuclides, we must also consider production. In this case, Eq. (32) must be modified to include a sum over all parent radionuclides. Consider a radionuclide decay chain

$$1 \rightarrow 2 \rightarrow 3 \rightarrow \ldots \rightarrow r\text{-}p\text{-}1 \rightarrow r\text{-}p \rightarrow \ldots \rightarrow r$$

The equations for radioactive decay are

$$\frac{dN_1}{dt} = -\lambda_1 N_1$$

$$\frac{dN_2}{dt} = -\lambda_2 N_2 + \lambda_1 N_1$$

$$\vdots \qquad \vdots$$

$$\frac{dN_r}{dt} = -\lambda_r N_r + \lambda_{r-1} N_{r-1} \quad 33.$$

The solution to these equations can be expressed as

$$N_r(t' + t) = \sum_{p=0}^{r-1} \mathcal{D}(r,r-p)\, N_{r-p}(t')$$

where $N_i(t)$ = inventory of isotope i at time t.

$$\mathcal{D}(r,r-p) = \prod_{q=1}^{p} \lambda_{r-q} \left\{ \sum_{i=1}^{p} \frac{e^{-\lambda_{r-i}\Delta t} - e^{-\lambda_r \Delta t}}{\prod_{\substack{j=0 \\ j\neq i}} (\lambda_{r-j} - \lambda_{r-i})} \right\} \quad 34.$$

The term $\mathcal{D}(r,r-p)$ can be interpreted as the probability that an atom of isotope r-p at time t' decays via $r-p \rightarrow r-p-1 \rightarrow \ldots \rightarrow r$ by time $t' + \Delta t$. Notice that $\mathcal{D}(r,r-p)$ depends only on Δt.

Thus for a chain of radionuclides, Eq. 32 becomes

$$\rho(i,r,t'+\Delta t) = \sum_{p=0}^{N_p(r)} \sum_{j=1}^{N_v} \frac{\mathcal{D}(r,r-p)}{N_v} \cdot \Big\{ M(j,r,r-p).\rho(i-k_j,r-p,t') + [1-M(j,r,r-p)].\,\rho(i-k_j-1,r-p,t') \Big\} \qquad 35.$$

The sum over parent isotopes is taken to $N_p(r)$ to indicate that the sum doesn't necessarily have to be taken to the top of the chain. The overlap fraction M(j,r,r-p) now depends on the velocity interval j and on the average isotope velocity for atoms of isotope r-p which decay to isotope r during Δt. The method for determing this average velocity will be discussed later.

To further aid understanding of Eq. (35), consider the following probabilistic interpretation. The probability that an atom of r-p in grid block $i-k_j$ at time t' will be in velocity interval j, will decay to species r and end up in grid block i at time $t=t' + \Delta t$ can be expressed as the product of three terms.

$P(j, i-k_j, r-p, t')$

$$= \text{(Probability of being in velocity interval } j)$$
$$\cdot \text{(Probability to decay from } r\text{-}p \text{ to } r \text{ in } t)$$
$$\cdot \text{(Probability to be in grid block } i \text{ at time } t)$$

$$= \left[\frac{1}{N_v}\right] \cdot \left[\mathcal{D}(r, r-p)\right] \cdot \left[M(j, r, r-p)\right]$$

Recall that only two grid blocks can contribute for any velocity interval j and $r\text{-}p \longrightarrow r$ transition. These are blocks $i\text{-}k_j$ and $i\text{-}k_j\text{-}1$. For all other blocks, the overlap fraction is 0.

<u>Velocity Model</u>

For transport of a single species, the overlap fraction for velocity interval j is given in Eq. 29 as

$$M(j) = 1 - (V_j \ \Delta t / \Delta x - k_j) \qquad 36.$$

When transporting chains of radionuclides, the overlap fraction becomes

$$M(j, r, r-p) = 1 - \left[\frac{\overline{V}(j, r, r-p)\,\Delta t}{\Delta x}\right] - k_j \qquad 37.$$

where

$$\overline{V}(j,r,r-p) = \sum_{q=0}^{p} \overline{T}_{r-q} V(j,r-q)/\Delta t \qquad 38.$$

and T_{r-q} is the mean time an atom spends as species r-q during decay of species r-p to species r in time Δt. Throughout the velocity model discussion we make the assumption that particles remain in the same velocity interval during radioactive decay over Δt. To understand the average velocity concept, consider the two-member chain

$$A \longrightarrow B$$

Assume that A is long-lived compared to Δt and that B is stable. In this case, A decays to B at essentially a constant rate during t. Thus, atoms of species A which decay to B during Δt spend, on the average, $\Delta t/2$ as species A and $\Delta t/2$ as species B. In this example

$$\overline{V}(j,B,A) = \frac{\frac{\Delta t}{2} \quad V(j,A) + \frac{\Delta t}{2} V(j,B)}{\Delta t}$$

or

$$\overline{V}(j,B,A) = \frac{1}{2} \; [V(j,A) + V(j,B)]$$

As a second example, assume isotope A is short-lived compared to Δt and that isotope B is stable. In this case,

$$\overline{T}_A = 1/_{\lambda_A}$$

and

$$V(j,B,A) = \frac{(1/\lambda_A)\ v(j,A) + (\Delta t - 1/\lambda_A)\ v(j,B)}{\Delta t}$$

Motivated by these two simple examples, we use the following approximations for the general decay chain.

$$r\text{-}p \longrightarrow r\text{-}p+1 \longrightarrow \ldots \longrightarrow r\text{-}1 \longrightarrow r.$$

If $\dfrac{1}{\lambda_{r-k}} \leq \dfrac{\Delta t}{p+1}, \quad 0 \leq k \leq p$

then $T_{r-k} = 1/\lambda_{r-k}$ 39.

Let $\left\{\dfrac{1}{\lambda_i}\right\}$ $i = 1, n;\ n < p+1$ be the set of all values of λ which meet the criterion of Eq. (39). Then for any species r-k such that

$\dfrac{1}{\lambda_{r-k}} > \Delta t/p+1$

we set $\overline{T}_{r-k} = \dfrac{\Delta t - \sum_{i=1}^{n} 1/\lambda_i}{p+1-n}$ 40.

In case $\dfrac{1}{\lambda_{r-k}} \leq \dfrac{\Delta t}{p+1}$ for all $k = o,p$

then $\overline{T}_{r-k} = \dfrac{\dfrac{\Delta t}{\lambda_{r-k}}}{\sum_{q=0}^{p} \dfrac{1}{\lambda_{r-q}}}$ 41.

To examine the accuracy of this model, consider the two member chain $r\text{-}1 \rightarrow r$. The probability that, in time interval Δt, an atom of species r - 1 decays to species r which survives to the end of Δt can be written as follows:

$$dP(r-1 \rightarrow r) = \left(e^{-\lambda_{r-1}t}\right)\left(\lambda_{r-1}\,dt\right)\left(e^{-\lambda_r(\Delta t - t)}\right) \qquad 42.$$

The first term in parentheses represents the probability that species r - 1 survives to time t. The second term represents the probability that species r - 1 decays to species r in time increment dt. The third term represents the probability that species r survives from time t to time Δt. Thus, for this case,

$$\overline{T}_{r-1} = \frac{\int_0^{\Delta t} t\lambda_{r-1}e^{-\lambda_{r-1}t}\,e^{-\lambda_r(\Delta t - t)}\,dt}{\int_0^{\Delta t} \lambda_{r-1}e^{-\lambda_{r-1}t}\,e^{-\lambda_r(\Delta t - t)}\,dt} \qquad 43.$$

The solution to Eq. (43) can be written as

$$\overline{T}_{r-1} = \frac{e^{(\lambda_r - \lambda_{r-1})\Delta t}}{e^{(\lambda_r - \lambda_{r-1})\Delta t} - 1}\Delta t - \frac{1}{\lambda_r - \lambda_{r-1}} \qquad 44.$$

$\overline{T}_r$ is then set to $\overline{T}_r = \Delta t - \overline{T}_{r-1}$.

Consider the case where the half-life of species r-1 is short and the half-life of species r is long compared to Δt.

Then $\lambda_{r-1}\Delta t \gg 1$, $\lambda_r\,\Delta t \ll 1$

and $\lambda_{r-1} \gg \lambda_r$.

In this case, Eq. (43) can be shown to give

$$\overline{T}_{r-1} \approx 1/\lambda_{r-1}$$

Similarly, if the half-lives of both species are long compared to Δt, one can show that $\overline{T}_{r-1} \approx 1/2\,\Delta t$

Thus, for the two species case, the exact solution of Eq. (44) produces the same special case results as our earlier examples. Exact calculation of $\overline{T}_{r-q}$ becomes difficult for chains of more than two species. However, we can compare our simple model as represented by Eqs. (39), (40) and (41) with the exact solution given by Eq. (44) for a two-member chain.

As a first example, consider the following problem

$$\Delta t = 1000 \text{ yr} \quad \text{and}$$

half-life of isotope B = $T_{1/2}$ (B) = 10,000 yrs.

We will examine $\overline{T}_A$ for several values of $T_{1/2}$ (A)

Thus,

$$\lambda_B = \frac{\ln 2}{10000} = 6.93 \times 10^{-5} \text{ yr}^{-1}$$

For this case, the NWFT/DVM velocity model gives

$$T_A = \frac{1}{\lambda_A} \qquad \text{for } \frac{1}{\lambda_A} \leq \Delta t/2$$

$$T_A = \Delta t/2 \qquad \text{for } 1/\lambda_A > \Delta t/2$$

$$T_B = \Delta t - \bar{T}_A$$

Comparison between the NWFT/DVM model and the exact solution is shown in Figure 19.

As a second example, let

$\Delta t = 1000$ years

$T_{1/2}(B) = 200$ years

Then $\lambda_B = \frac{\ell n 2}{200} = 3.47 \times 10^{-3}\ \text{yrs}^{-1}$

We again examine $\bar{T}_A$ for several values of $1/\lambda_A$. The NWFT/DVM model gives

$$\bar{T}_A = \frac{\frac{1}{\lambda_A}}{\frac{1}{\lambda_A} + \frac{1}{\lambda_B}} \Delta t \quad , \frac{1}{\lambda_A} \leq \Delta t/2$$

$$\bar{T}_A = \Delta t - 1/\lambda_B \quad , \frac{1}{\lambda_A} > \Delta t/2$$

The comparison for this case is shown in Figure 20. Figures 19 and 20 indicate that, for the two member chain, the NWFT/DVM velocity model is reasonably accurate. The adequacy of the velocity model is illustrated in several comparison problems presented in the NWFT/DVM user manual.

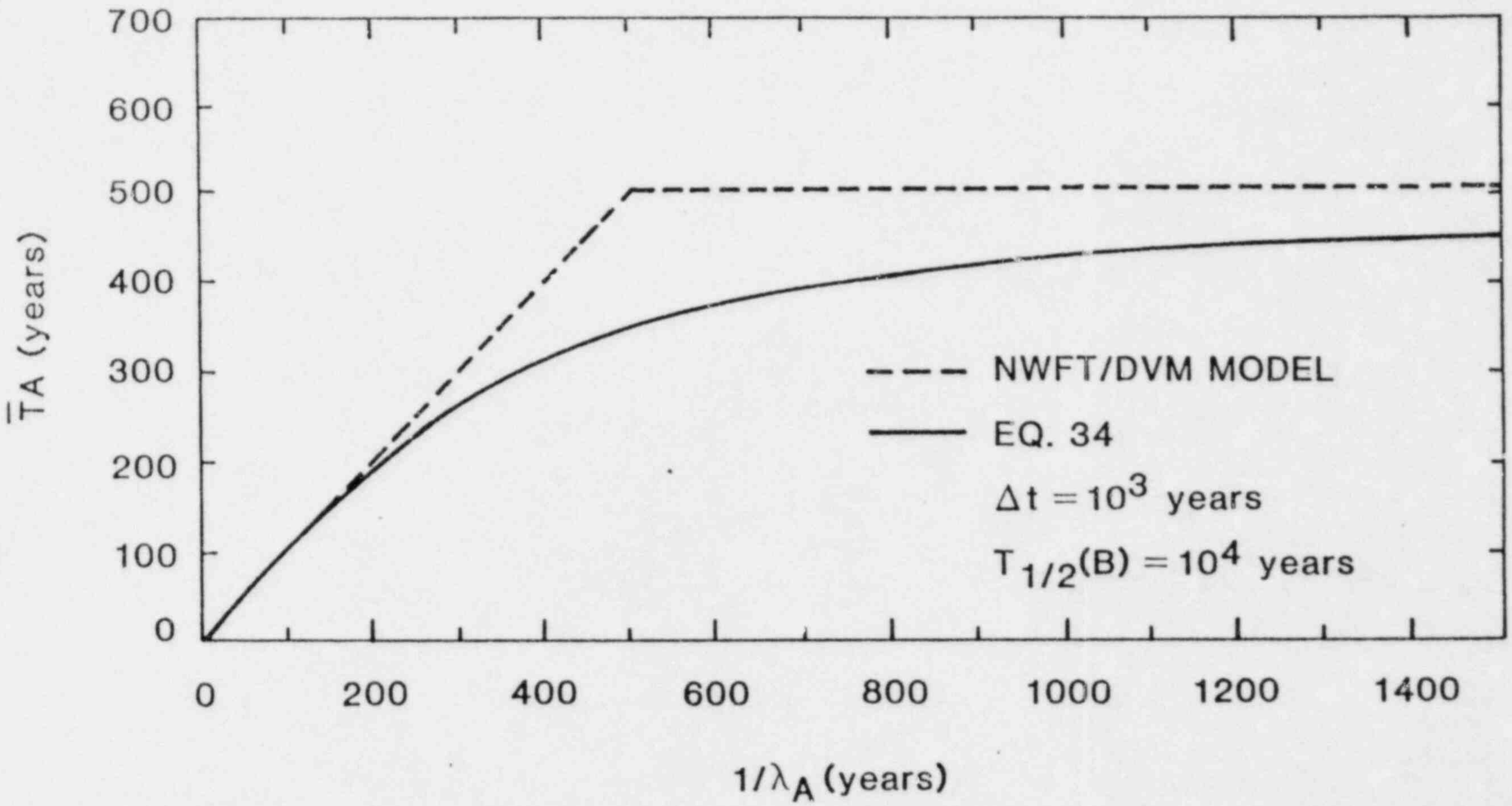


Figure 19. Comparison Between the NWFT/DVM Velocity Model and the Exact Solution for a Two Member Chain (First Example)

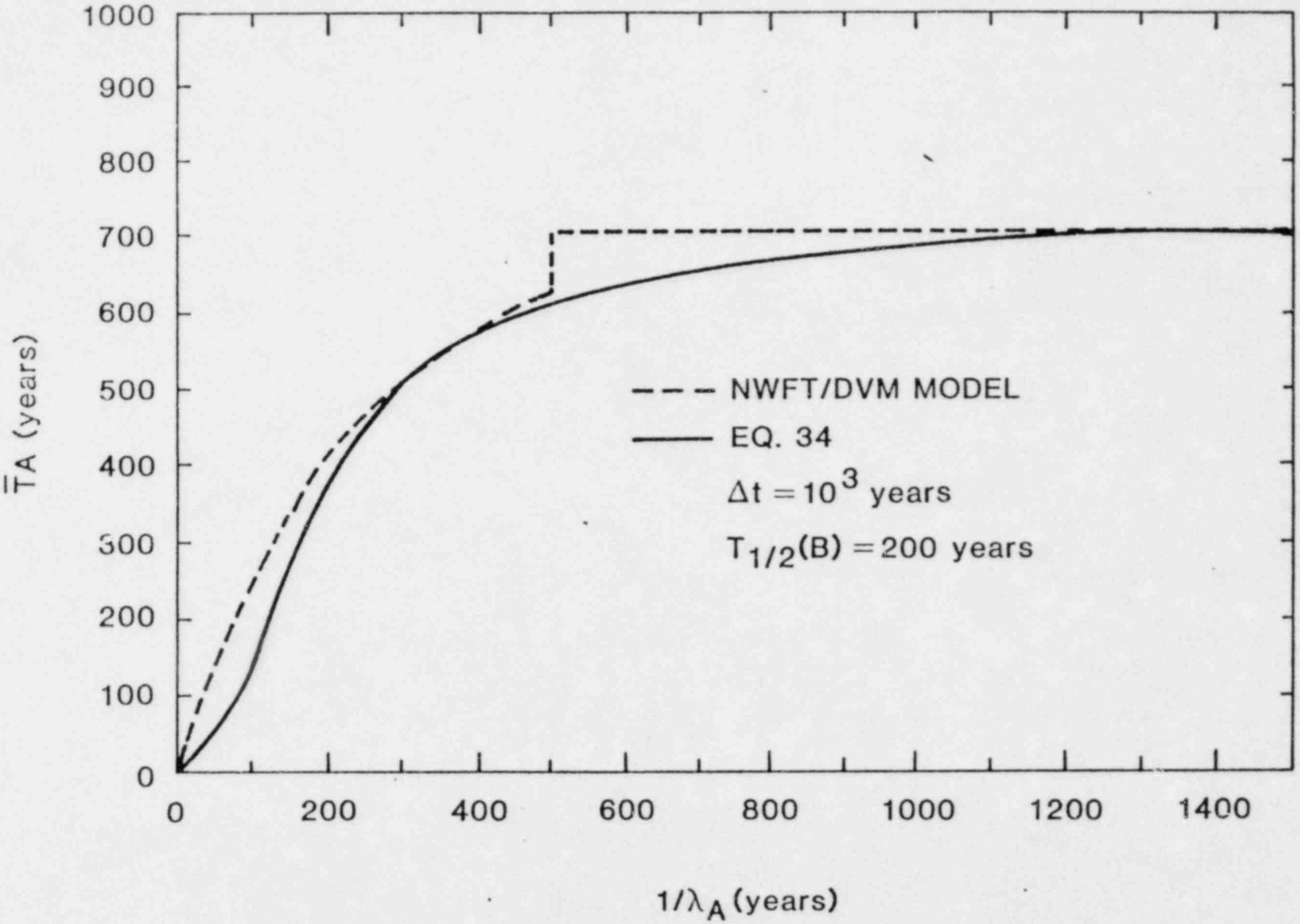


Figure 20. Comparison Between the NWFT/DVM Velocity Model and the Exact Solution for a Two Member Chain (Second Example)

DVM Subroutines

The calling sequence for use of the DVM option is shown on the next flow chart (Figure 21). After the flow calculations, subroutine METHOD is accessed from ANAMOD. Setting option 13 to zero indicates that DVM is to be used. Inside the dashed lines are the calls made by METHOD.

Subroutine DXDT finds the time step, the space step, and the number of designated source blocks to be used. The logic is discussed in detail in a later section. DXDT uses BRANCH to set up decay chain information needed to find effective leach times. It uses SORT to arrange effective leach times, half-lives, and average migration times into ascending order. All DXDT logic is bypassed (except for the number of source blocks) if the user inputs nonzero DX and DT on the DVM control card. (See problem 5 or the Users Manual).

Subroutine SETUP has 6 functions. First, isotopic velocity distributions are determined. Second, the grid block structure is set for source blocks, migration path blocks, and (possibly) collector blocks to catch material assigned negative velocities. Third, velocities are assigned to those particles which decay over a time step according to the velocity model above. Fourth, the transport (B) arrays are constructed using the decay and production factors returned from BRANCH. Fifth, the discharge

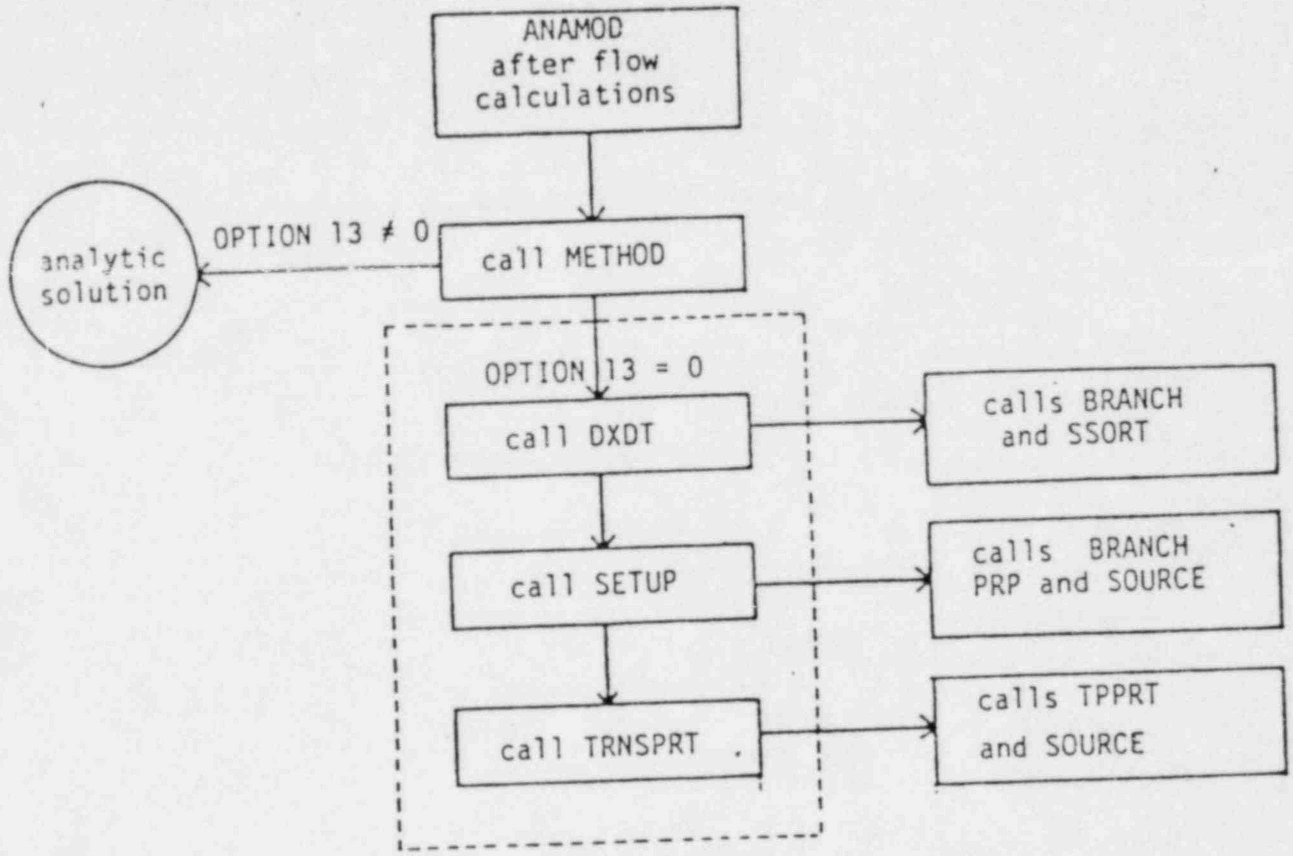


Figure 21. DVM Flow Chart

factor array is found with function PRP serving as the integral evaluator. Sixth, the initial call to SOURCE is made.

The transport of material from grid block to grid block over a time step is done in TRNSPRT. TRNSPRT loops over time from TR to TUB. During each time step, radionuclide transport is performed, source material is placed in the source blocks (by calling SOURCE), radionuclide discharge rates are calculated, and results are optionally printed (by calling TPPRT).

Sample Problems 3A and B can be attempted with the information presented thus far.

Source Model

The source model accounts for both leach and solubility limits by considering three different radionuclide inventories; namely, (1) unleached (2) leached but undissolved, and (3) dissolved. In the present version of DVM, the leach rate is assumed constant. However, generalization to a time-dependent leach rate is straightforward.

For a constant leach-rate model, the quantity of waste matrix leached during time step Δt is

$$\Delta m = \frac{m_0}{\tau} \Delta t \qquad 45.$$

where m_0 is the initial mass of waste matrix and τ is the leach time. The concentration $\mathcal{N}(r, t + \Delta t/2)$ of species r in the waste matrix at time $t + \Delta t/2$ is determined from

$$\mathcal{N}(r,t + \Delta t/2) = \sum_{p=0}^{N_p(r)} \mathcal{D}(r,r-p)\mathcal{N}(r-p, t- \Delta t/2) \qquad 46.$$

Thus the amount of species r leached between t and t + Δt is approximated as

$$\Delta N(r,t + \Delta t/2) = \mathcal{N}(r,t + \Delta t/2) \frac{m_o \Delta t}{\tau} \qquad 47.$$

Quantity $\Delta N(r, t + \Delta t/2)$ is placed in the undissolved inventory which is given by

$$N_u (r,t + \Delta t/2) = \sum_{p=0}^{N_p(r)} \mathcal{D}(r,r-p)N_u (r-p, t- \Delta t/2) + \Delta N(r,t+\frac{\Delta t}{2}) \qquad 48.$$

where $N_u (r,t)$ represents the quantity of species r in the undissolved inventory at time t. The quantity of species r which enters solution between t and t + Δt is

$$\Delta N_s(r,t + \Delta t/2) = MIN [N_u(r,t + \Delta t/2), C_s Q \Delta t] \qquad 49.$$

where $\Delta N_s(r, t + \Delta t/2)$ is the amount of species r placed in solution between t and t + Δt, C_s is the solubility limit in mass radionuclide per mass fluid, and Q is the fluid flow rate in mass fluid per time.

A flow chart for the subroutine SOURCE is presented in Figure 22. Some details and terminology are given here. The initial call to SOURCE is designated by putting a zero in the subroutine argument list. The initial call to SOURCE can be found in routine SETUP. Inventories are established at release time, T_R. The LLONLY parameter is user input on the DVM control card. Its function:

LLONLY = 0 the source rate is controlled only by the leach time

LLONLY = 1 the source rate is controlled only by solubility limitations

LLONLY = 2 the source rate is automatically determined at each time step (leach- or solubility-limited) by routine SOURCE.

An assumption is made here that leaching begins at time T_R. Thus, the inventory after being aged to T ($\eta(T_R)$) is the unleached inventory at T_R for LLONLY = 0 or 2. The undissolved inventory, $N_u(T_R)$, is initialized to zero for LLONLY = 2. For LLONLY = 0, the undissolved inventory is not used. For LLONLY = 1 all material is instantly available for solution (i.e., there is no unleached inventory). In this case, we set $N_u(T_R) = \eta(T_R)$ and then $\eta(T_R) = 0$.

The remainder of the flow chart description is valid for all calls to SOURCE. If leaching is not in progress at time t (i.e., $t > T_R + \tau$ or LLONLY = 1) then the amount leached over DT is zero, $\Delta\eta(DT) = 0$. In the case $t > T_R + \tau$ and LLONLY = 0 we immediately return to the calling program. In the case LLONLY = 1 there may still be source from the undissolved inventory even though leaching has terminated.

If leaching is in progress, we first age the unleached inventory to the midpoint of the next time step, t + DT/2. With a constant leach rate, the amount leached over DT is then approximated by

$$\Delta\eta(DT) = \frac{DT}{\tau}\, \eta\left(t + \frac{DT}{2}\right)$$

For LLONLY = 0 that is the source so that .

$$N_s(DT) = \Delta\eta(DT)$$

For LLONLY = 1 or 2 the undissolved pile is aged to t + DT/2. The amount available for solution at t = DT/2 is then

$$N_u(t+DT/2) = N_u(t+DT/2) + \Delta\eta(DT)$$

The amount that can enter solution may be governed by the solubility limit. First, average solubility limits, $\overline{C}_s$ (i.e. the

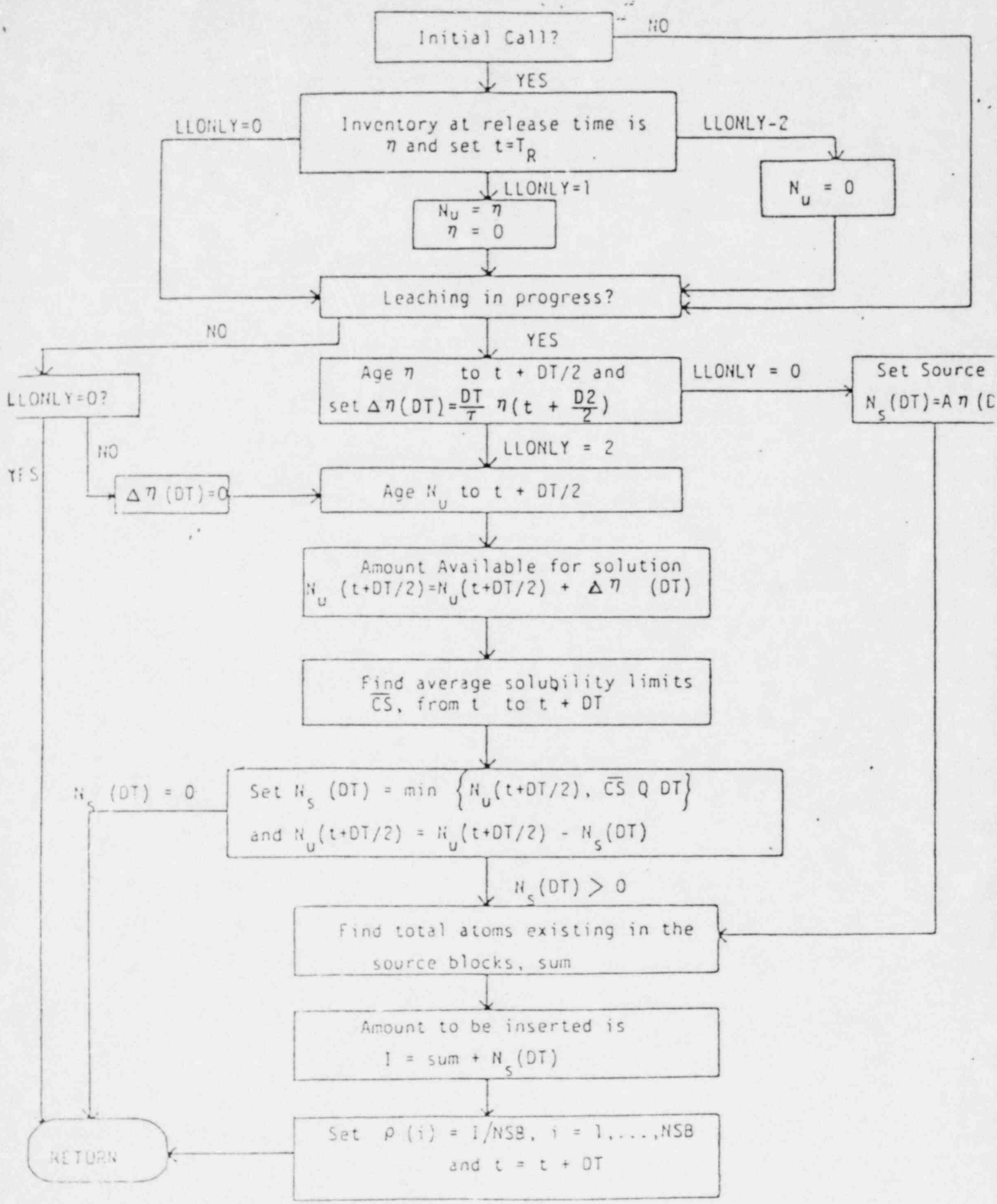


Figure 22. Source Model Flow Chart

average isotopic mass fraction times the solubilities) are found from t to t + DT. Then the source is

$$N_s(DT) = \min \left\{ N_u\ (t + DT/2),\ \bar{C}_s\ Q\ DT \right\}$$

where Q is the volumetric flow rate in ft^3/y.

If the source, summed over all isotopes, is zero (or insignificant) the routine is bypassed on this and future calls. Otherwise we update the undissolved inventory,

$$N_u\ (t + DT/2) = N_u\ (t + DT/2) - N_s(DT).$$

Then, the total material in the source blocks is distributed uniformly across those blocks. That is, we set SUM equal to the amount in the source blocks at time t. Then each source block is assigned the same amount, I/NSB, where

$$I = SUM + N_s\ (DT).$$

In particular this process assumes the source remains uniformly distributed through the depository. Finally, t is updated to t + DT in anticipation of the next call to SOURCE.

Determining total discharge of species r from time t to time t + Δt can be viewed as evaluating

$$\delta(r,\ t,\ \Delta t) = \sum_{p=o}^{N_p(r)} \sum_{i=1}^{NB(r,r-p)} F(r,r-p,i)\rho(r-p,\ N_x-i+1,t) \qquad 50.$$

where

NB (r, r-p) marks the grid block farthest from the boundary that contains precursor r - p and can contribute to the discharge of r, F(r, r - p, i) is the fraction of species r - p in grid block N_x - i + 1 that discharges as species r, and ρ(r - p, N_x - i + 1,t) is the number of atoms of species r - p in grid block N_x - i + 1 at time t.

The determination of array F (and as a by-product, the array NB) is the subject of the following discussion. As seen by the notation, F is independent of time. Hence, F can be constructed during the setup process and stored. Furthermore, F can be determined in a potentially different manner for each p. However, with simplifying assumptions concerning velocities and production, we reduce the cases to p = 0 and p $\geq$ 1.

Case 1 p=0

Here, we are concerned only with atoms of species r at time t that discharge as species r during the time increment Δt. Recall that each grid block has its contents of species r partitioned into N_v equally weighted velocity packets. Packet j is assigned velocity v(j, r), j = 1, ..., N_v. So packet j in grid block N_x - i + 1 can contribute to the discharge of species r if

$$V(j, r) \cdot \Delta t \geq (i - 1) \cdot \Delta x.$$

The measure of its contribution and the time required to discharge depends on the Courant number,

$$\mathscr{C}(j, r) = v(j, r). \frac{\Delta t}{\Delta x}$$

A packet may totally or partially traverse the boundary as exemplified in Figure 23.

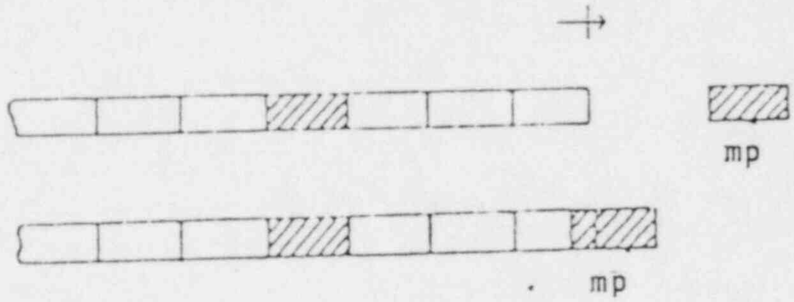


Figure 23. Total and partial discharge of a typical packet of isotope r

The contribution factor of packet j in grid block $N_x - i + 1$ is then,

$$h(j, r) = \begin{cases} 0 & \text{for } \left[[\mathscr{C}(j,r)]\right] < i - 1 \\ \mathscr{C}(j,r) - \left[[\mathscr{C}(j,r)]\right] & \text{for } \left[[\mathscr{C}(j,r)]\right] = i-1 \\ 1 & \text{for } \left[[\mathscr{C}(j,r)]\right] > i-1 \end{cases}$$

If there were no radioactive decay, F could now be determined by

$$F(r,r,i) = \sum_{j=1}^{N_v} \frac{h(j,r)}{N_v}$$

where $1/N_v$ represents the fraction of grid block i that is assigned velocity $v(j,r)$.

However, with decay the fraction F should be reduced to account for radioactive decay which occurs before the packet crosses the discharge boundary. In order to calculate the fraction of an isotope that survives decay until it discharges we need the time, $t(j, r, i)$,

$$o < t(j,\ r,\ i) < \Delta t$$

that a packet crosses the boundary.

Referring to Figure 23, we define the time to discharge as the time at which the spatial midpoint, m_p, crosses the boundary. That is,

$$t(j,r,i) = \begin{cases} \dfrac{i-1/2}{\mathscr{C}(j,r)}\ \Delta t & \text{for } \left[[\mathscr{C}(j,r)]\right] > i-1 \\ \\ \dfrac{\mathscr{C}(j,r)+i-1}{2\mathscr{C}(j,r)}\Delta t & \text{for } \left[[\mathscr{C}(j,r)]\right] = i-1 \end{cases}$$

Thus, the array F for the case p = o is defined by

$$F(r,r,i) = \frac{1}{N_v} \sum_{j=1}^{N_v} h(j, r) \exp^{(-\lambda_r t(j,r,i))} \qquad 51.$$

Note that $NB(r,r) = \left[\left[\mathscr{C}(N_v, r) + 1\right]\right]$.

<u>Case 2</u> $p \geq 1$

Consider the subcase p = 1 as a model.

Suppose an atom of species r - 1 at the beginning of time interval Δt is distance L from the discharge point. We determine the probability that this atom decays to species r and discharges in Δt as the product of probabilities of the following three independent events.

Event 1. The atom is of species type r - 1 after time t_d

$$0 < t_d < \Delta t.$$

Event 2. During **infinitesimal time dt_d, the atom decays to** species type r.

Event 3. The atom remains as species r in the time remaining to discharge.

These events have the probabilities:

$$\text{pr (Event 1)} = e^{-\lambda_{r-1} t_d}$$

$$\text{pr (Event 2)} = f(r-1, r)\lambda_{r-1}\, dt_d$$

$$\text{pr (Event 3)} = e^{-\lambda_r TD}$$

where,

$f(r-1,r)$ is the decay fraction of species r-1 to r and TD is the time remaining to discharge, i.e..

$$TD = \frac{L - v(r-1)\, t_d}{v(r)} .$$

Note that $v(r)$ and $v(r - 1)$ are picked from the velocity distributions for species r and r - 1. However, they are chosen from the same velocity subinterval and thus the velocity index j is dropped.

The production fraction of species r by species r - 1 is then found by integrating over possible times of decay,

$$P(r,r-1) = \lambda_{r-1} f(r-1,r) \int_{T_1}^{T_2} \exp(-\lambda_{r-1} t_d) \exp\left(-\lambda_r \frac{L - v(r-1)t_d}{v(r)}\right) dt_d \qquad 52.$$

$$= \lambda_{r-1} f(r-1,r) \exp\left(\frac{-\lambda_r L}{v(r)}\right) \cdot \left(\frac{1/v(r-1)}{\frac{\lambda r}{v(r)} - \frac{\lambda r-1}{v(r-1)}}\right) \cdot \exp\left[\left(\frac{\lambda r}{v(r)} - \frac{\lambda_{r-1}}{v(r-1)}\right) \cdot v(r-1)t_d\right] \Bigg|_{T_1}^{T_2}$$

The above integration is valid so long as

$$\frac{\lambda_r}{V(r)} \neq \frac{\lambda_{r-1}}{V(r-1)}$$

Otherwise, 52 is replaced by

$$P(r,r-1) = \lambda_{r-1} f(r,r-1) e^{\frac{-\lambda_r L}{V(r)}} (T_2 - T_1) \qquad 53.$$

Here, T_1 and T_2 define the earliest and latest times that an atom of species r-1 at a distance L from the boundary can decay and then discharge as species r. Their definitions are given below. The minimums and maximums in their definitions are necessitated by the number of different ways that velocities can be related.

The following example may serve to elucidate the definitions. Suppose $v(r-1) > v(r) > 0$ and $v(r-1)\ \Delta t > v(r)\ \Delta t > L$. Note that both velocities are large enough to carry particles the distance L over Δt. In particular, $v(r)\ \Delta t > L$ implies that an atom can decay instantly to species r and discharge as species r. That is, $T_1 = 0$. On the other hand, decay must occur before an atom of species r-1 reaches the boundary. So, time of decay must be less than the travel time of species r-1 over the distance L. Thus, $T_2 = L/v(r-1)$.

To aid in the general definitions of T_1 and T_2 we use the values Tmin and Tmax. Tmin and Tmax are the minimum and maximum migration times over distance L. If Tmin $> \Delta t$ there can be no contribution to discharge from distances greater than or equal to

L. Also, Tmax is not allowed to be greater than Δt, since we are constrained to the time step Δt.

By examining in turn the remaining order relationships of $(v(r), v(r-1), 0)$ and $(v(r)\ \Delta t, v(r-1)\ \Delta t, L)$, the following formulae can be verified.

$$T_{min} = \frac{L}{\max(v(r), v(r-1))} \qquad 54.$$

$$T_{max} = \begin{cases} \dfrac{L}{\min(v(r), v(r-1))} & \text{if } 0 < \dfrac{L}{\min(v(r), v(r-1))} < \Delta t \\ \Delta t & \text{otherwise} \end{cases} \qquad 55.$$

$$T_1 = \begin{cases} \dfrac{L - T_{min} v(r)}{v(r-1) - v(r)} & \text{if } v(r-1) \neq v(r) \\ 0 & \text{otherwise} \end{cases} \qquad 56.$$

$$T_2 = \begin{cases} \dfrac{L - T_{max} v(r)}{v(r-1) - v(r)} & \text{if } v(r-1) \neq v(r) \\ T_{max} & \text{otherwise} \end{cases} \qquad 57.$$

In equations 56 and 57 it is not obvious, a priori, whether $T_1 \geq T_2$ or $T_2 \geq T_1$. We avoid this problem by taking the absolute value of the integral in equations 52 and 53. Certainly, if

$$T_{min} > \Delta t$$

or

$$v_r < 0$$

there is no contribution to discharge of species r from these velocities, so calculations 54 through 57 should be bypassed. This also ensures $T_1 \geq 0$ and $T_2 \geq 0$.

In order to generalize 52 and 53 to cases $p > 1$, one could consider the set

$$\left\{t(r - p), \ldots, t(r - 1)\right\} ,$$

where $t(r - k)$ denotes the time interval over which species $r - k$ does not decay and travels with velocity $v(r - k)$, $k = 1, \ldots, p$. Then $dt(r - k)$ would be that infinitesimal time for decay from species $r - k$ to species $r - (k-1)$. In this fashion, $p - 1$ nested integrals must be evaluated. However, finding the $2(p - 1)$ limits of integration then becomes a formidable task.

As an option we treat the decays of species

$$r - p \rightarrow r - (p - 1) \rightarrow \ldots \rightarrow r - 1$$

as a single process over time

$$t_d = \sum_{K=1}^{P} t(r - k).$$

The velocity achieved during time t_d is approximated by the arithmetic average of species' velocities, i.e., define $v(rp)$ by

$$v(rp) = \frac{1}{P} \sum_{K=1}^{P} v(r - k).$$

This is a reasonable approximation for small t_d (see velocity model treatment), which is generally the case in this analysis.

Event 1 is then restated as:

Event 1': The atom begins t as type r - p and is of type r - 1 at t_d.

Events 2 and 3 remain the same with TD replaced by

$$TD = \frac{L - v(rp)\, t_d}{v(r)} \quad .$$

The probability of event 1' is the Bateman production coefficient over t_d,

$$\prod_{k=2}^{p} f(r-k, r-(k-1))\, \lambda_{r-k} \quad \sum_{\ell=2}^{p} \left\{ \frac{e^{-\lambda_{r-\ell} t_d} - e^{-\lambda_{r-1} t_d}}{\prod_{\substack{m=1 \\ m \neq \ell}}^{p} \cdot (\lambda_{r-m} - \lambda_{r-\ell})} \right\}.$$

where f(r - k, r - (k - 1)) is the decay fraction of species r - k to species r - (k - 1). The production fraction is then

$$P(r, r-p) = \prod_{K=1}^{p} f(r-k, r-(k-1))\, \lambda_{r-k} \quad .$$

$$\int_{T_1}^{T_2} \left\{ \sum_{\ell=2}^{p} \frac{e^{-\lambda_{r-\ell} t_d} - e^{-\lambda_{r-1} t_d}}{\prod_{\substack{m=1 \\ m \neq \ell}}^{p} (\lambda_{r-m} - \lambda_{r-\ell})} \right\} e^{-\lambda_r \left(\frac{L - v(rp) t_d}{v(r)} \right)} dt_d \qquad 58.$$

If $\frac{\lambda_r}{v(r)} \neq \frac{\lambda_{r-k}}{v(rp)}$ for all k = 1, ..., p, then integrating 58 and and rearranging terms yields

$$P(r, r-p) = \prod_{k=1}^{p} f(r-k, r-(k-1)) \; \lambda_{r-k} e^{\frac{-\lambda_r}{V(r)} L}$$

$$\sum_{\ell=1}^{p} \left\{ \prod_{\substack{m=1 \\ m\neq\ell}}^{p} \frac{1}{(\lambda_{r-m} - \lambda_{r-\ell})} \left[\frac{1/v(rp)}{\frac{\lambda_r}{v(r)} - \frac{\lambda_{r-\ell}}{v(rp)}} e^{\left(\frac{\lambda_r}{v(r)} - \frac{\lambda_{r-\ell}}{v(rp)}\right) v(rp) t_d} \Bigg|_{T_1}^{T_2} \right] \right\} \qquad 59.$$

If for p = 1 we define $\prod_{\substack{m=1 \\ m\neq\ell}}^{p} \left(\lambda_{r-m} - \lambda_{r-\ell}\right) = 1$, then equation 59 contains equation 52.

If for some $\ell = \ell'$, $\lambda r/V(r) = \lambda_{r-\ell'}/v(rp)$, then the sum $\sum_{\ell=1}^{p}$ is replaced by $\sum_{\substack{\ell=1 \\ \ell\neq\ell'}}^{p}$ and the term

$$\prod_{k=1}^{p} f(r-k, r-(k-1)) \; \lambda_{r-k} \; \exp\left(\frac{-\lambda_r}{v(r)} L\right) \cdot \frac{T_2 - T_1}{\prod_{\substack{m=1 \\ m\neq\ell'}}^{p} (\lambda_{r-m} - \lambda_{r-\ell'})}$$

is added.

The determination of T_1 and T_2 proceeds as in equations 54 through 57 with v(r - 1) replaced by v(rp).

Since v(r) = v(j, r) for some velocity interval j = 1, ..., NV , v(rp) and thus P(r, r - p) depends on j. We can use the above model for defining F by relating distance L to grid blocks. We make the assumption that all material in a packet is located at the grid block midpoint. That is, let

$$L = (i - 1/2)\Delta x$$

To define F first set

$$\mathscr{P}(j,r,r\text{-}p]) = \begin{cases} P(j,r,r\text{-}p) \text{ (evaluated at L) } 0 \le T_{min} \le T_{max} < \Delta t \\ 0 \qquad\qquad\qquad\qquad\qquad \text{otherwise} \end{cases}$$

Then array F is given by

$$F(r,r\text{-}p,i) = \frac{1}{N_Y} \sum_{j=1}^{N_v} \mathscr{P}(j,r,r\text{-}p) \qquad 60.$$

Remark: It may happen that $v(j, rp)\Delta t < \Delta x/2$ for all j = 1, ..., N_v. In this case, some of species r in grid block N_x should discharge during Δt. However, because we take L as the distance from the grid block midpoint to the discharge location (i.e., for block N_x $L = \Delta x/2$), the discharge model presented above would produce no discharge of species r. In this special case, L is decreased to L' such that

$$v(j, r)\ \Delta t > L' \quad \text{or} \quad v(j, rp)\ \Delta t > L'$$

for some j values. Then for grid block N_x (i.e., i - 1),

$$F(r, r - p, i) = \frac{L'}{L} \frac{1}{N_v} \sum_{j=1}^{N_v} \mathscr{P}(j, r, r - p) \text{ (evaluated at } L') \qquad 61.$$

Further, note that NB(r, r - p) can be defined by the maximum value of i that yields $\mathscr{P}(j, r, r - p) \neq 0$ for any j.

Together, equations 51 through 61 completely define array F.

Sample Problem 4 can be attempted with the information presented thus far.

Space Step and Time Step Criteria

Proper space and time-step selection require consideration of the following: 1) minimization of numerical dispersion, 2) source term accuracy, 3) proper resolution of discharge curves and 4) machine storage and execution time.

Numerical Dispersion. In DVM, numerical dispersion is primarily controlled by the Courant number which is defined for isotope r as

$$\mathscr{C}(r) = \frac{\overline{v}(r)\ \Delta t}{\Delta x}$$

Analysis of numerical dispersion in DVM indicates that numerical dispersion can usually be adequately controlled if

$$\min_{r} \left\{\mathscr{C}(r)\right\} \geq 1$$

Numerical dispersion can also be affected by the length of the contaminant pulse. Clearly if the pulse extends over only 1 or 2 grid blocks, some pulse smearing will result. The length of a contaminant pulse can be approximated as

$$P_L(r) = NSB \cdot \Delta x + \overline{V}(r) \quad \tau_{eff} \quad (r)$$

where $P_L(r)$ = pulse length for isotope r

NSB = number of source blocks

$\tau_{eff}(r)$ = effective leach time for isotope r. The effective leach time is the time actually required for all of isotope r to enter solution. If r is solubility-limited, th[illegible] time will generally be greater than [illegible] leach time.

Therefore, the number of grid blocks across the pulse is

$$NPB(r) = P_L(r) / \Delta x$$

It is recommended that

$$\min_r \left\{ NPB(r) \right\} \geq 10$$

Source Term Accuracy. The amount of source injected into the source grid blocks over time step t is based on the unleached and the leached but undissolved inventories at the midpoint of the time interval. Thus, the value of t should be influenced by the minimum isotope half life. It is recommended that

$$\Delta t \leq 2 \left[\min_r \left\{ T_{1/2}(r) \right\} \right]$$

Resolution of Discharge Curves. The time step should be sufficiently small to assure adequate definition of the breakthrough portions of radionuclide discharge curves. One measure of the breakthrough width is σ_t, the standard deviation in time of the Gaussian distribution underlying the error function shape of the breakthrough curve. The value of σ_t is given by

$$\sigma_t(r) = \sqrt{2 \alpha L_p} / v(r)$$

where α is dispersivity (ft), L_p is migration path length (ft), and $\bar{v}(r)$ is the average velocity for isotope r.

It is recommended that

$$\Delta t \leq 2 \left\{ \min_r \sigma_t (r) \right\}$$

<u>Machine Storage and Execution Time</u>. Storage and execution time considerations suggest maximizing Δx and Δt. However, in addition to the criteria suggested above, Δx should not be greater than the source length (DEPLEN) and Δt should not be greater than about 1/2 the minimum isotope migration time. Present array dimensions require that

$$L_p / \Delta x \leq 1400.$$

It is important to note that the above criteria needn't be applied necessarily to all isotopes in a decay chain. For example, a short-lived daughter of a long-lived parent may discharge only due to the parent discharge. Thus, its numerical dispersion and discharge curve are controlled by those of the parent. For practical considerations this means that the above guidelines do not have to be applied necessarily to such an isotope. The test for discharge from the source for isotope r is currently

$$T_m(r) \leq 10\, T_{1/2}(r)$$

Finally, it is possible that these criteria cannot all be satisfied. Increments Δx and Δt must then be compromised in some fashion.

The space and time steps for DVM can be read as input or can be internally calculated by the routine DXDT. The following flow chart, Figure 24, shows the DXDT routine logic. The symbol * throughout the chart is used to indicate "minimum important." "Minimum" means the smallest value of the variable taken over all isotopes in a given decay chain. "Important" here is used to indicate those isotopes for which a significant portion of their discharge is due to their initial source. More specifically, an isotope is considered important if its average migration time is not very much greater than its half-life. In symbols

$$T_m(r) \leq N \cdot T_{1/2}(r) \quad \text{, some } N > 0,$$

for isotope r to be important. Currently in NWFT/DVM we set N=10. This means that according to our arbitrary classification, important isotopes are those for which average migration times are less than 10 half-lives. Thus, important isotopes discharge at least $(1/2)^{10}$ times 10^{-3} of their initial inventory. Otherwise, discharge is assumed to be controlled by a parent or is insignificant. It is largely for these important isotopes that DT and DX are adjusted. The adjustments are for source accuracy, discharge curve resolution, and minimization of numerical dispersion.

If DT is not input, it is initialized to

$$DT1 = 1/2 \min \left\{ \tau^*_{eff}, T_m \right\} \quad .$$

That is, DT1 is chosen to be the smaller of one-half the minimum important effective leach time and the minimum average migration time. Effective leach times are calculated from solubility limit considerations. Recalling routine SOURCE an amount $\overline{C_S}$ Q DT is input at each time step for those isotopes which are solubility limited. In general for such isotopes, the time required to completely dissolve the inventory of an isotope is then longer than τ. Therefore, effective leach time is a measure of time required to deplete the undissolved inventory. Using τ^{eff} as opposed to τ can often allow a larger initial guess at DT1. Further, DT1 is required to be no larger than 1/2 $T_m$min. This ensures that no material can travel from the source to discharge points in a single time step.

Next, DT1 is compared to important half-lives. There is a decay approximation in the SOURCE routine that will lose accuracy for DT1 $\gg T_{1/2}$. The approximation is that the average amount decayed or produced over DT can be estimated by the amount at DT/2. For DT = 2 $T_{1/2}$ the error is reasonably small. So we require

$$DT2 = \min (DT1,\ 2\ T_{1/2}).$$

Resolving curves means generating enough points to accurately describe curves. We do this by requiring at least one point on the breakthrough portion of the discharge curves. Recalling the discussion of selecting time increments for the analytic transport model output, we know the standard deviation in time of the breakthrough portion,

$$\sigma_T = \sqrt{2\alpha x} \; / \overline{\nu}_r .$$

So,

$$DT3 = \min \left\{ DT2, \; 2 \; \sigma^*_T \right\} .$$

This assumes that "unimportant" discharge curves are either insignificant or are controlled by some "important" parent.

Finally, from past experience we require some minimum number of time steps. That is,

$$DT = \min \left\{ DT3, \quad \frac{TUB - T_R}{C11} \right\}$$

Currently, C11 = 40.

If DX is not input it is initialized so that the minimum important Courant number is 1. So,

$$DX1 = \bar{\nu} * DT.$$

Recall that the Courant number, $\bar{\nu}$ DT/DX, plays an important role in minimizing numerical dispersion.

Next, the source pulse should be spread over a few grid blocks to avoid lowering of the peaks of discharge curves. The source pulse length is defined as

$$\bar{v} \cdot \tau^{eff} + \text{DEPLEN}$$

where

DEPLEN is the source (or effective depository) length (ft). Here we find the minimum important product of τ^{eff} and $\bar{\nu}$ over all isotopes. So,

$$\text{DX2} = \min \left\{ \text{DX1}, \frac{(\tau\text{eff } \bar{\nu})^{*} + \text{DEPLEN}}{\text{C4}} \right\}$$

where C4 is currently 10.

Also, the number of source blocks should be at least one. This number is calculated from DEPLEN/DX. So, we require

$$\text{DX3} = \min \left\{ \text{DX2, DEPLEN} \right\}$$

The amount of material in each grid block is stored over each time step. Arrays containing this information must be dimensioned in NWFT/DVM. Current dimensioning requires that the number of grid blocks be no greater than 1400. If $X/DX3 \leq 1400$ then set DX = DX3 and return. Otherwise, set DX = X/1400. Here X denotes the length from the left edge of the depository to the discharge point.

With DX larger than DX3 it is necessary to recheck Courant numbers. If the minimum important Courant number is no less than .9, DX and DT are deemed acceptable. If not, a compromise DT is calculated. Hopefully, a time step that gives the minimum

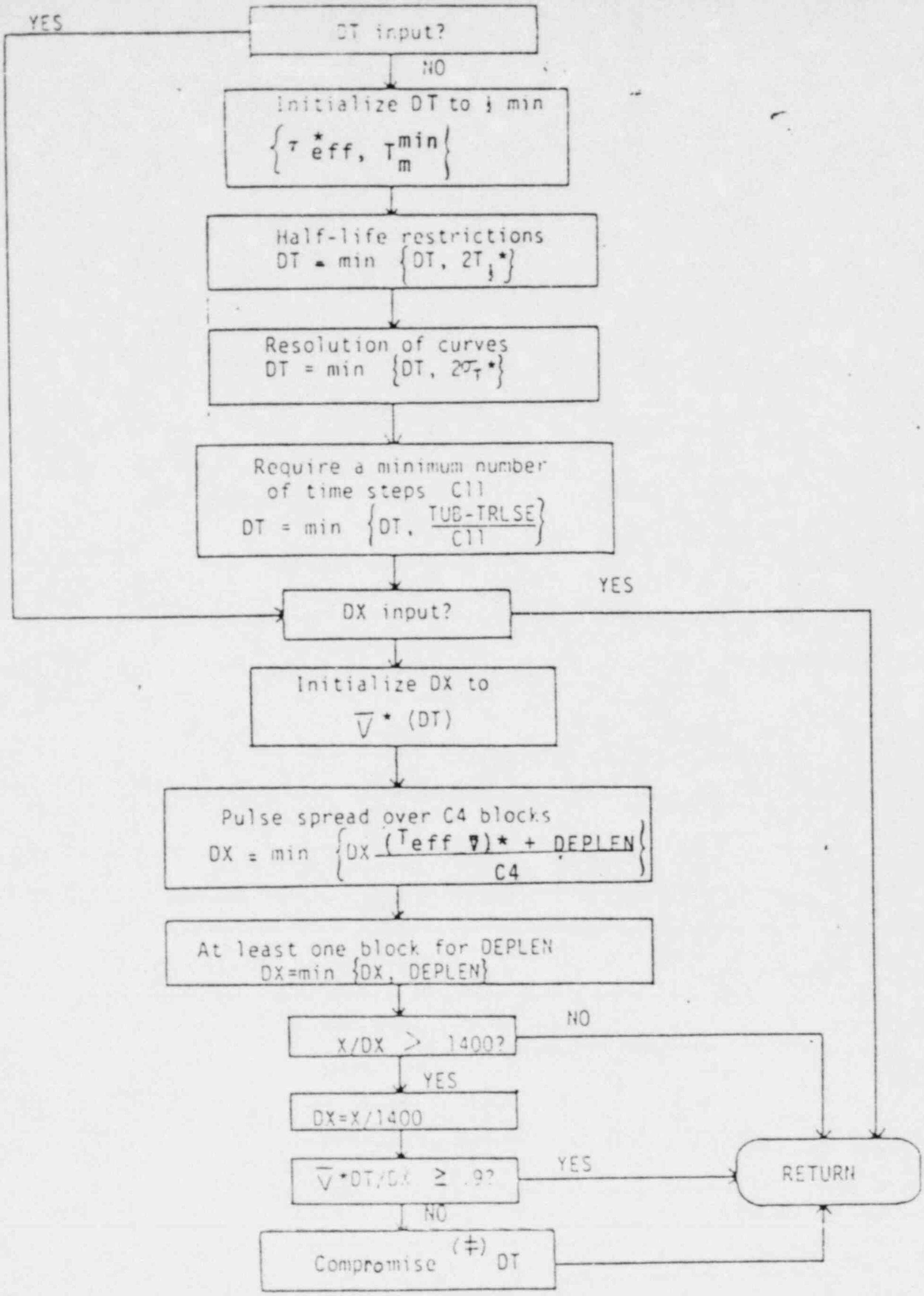


Figure 24. DXDT Flow Chart

[‡] 1) $DT = \frac{.9DX}{\bar{V}*}$

2) $DT = \min(DT, \tfrac{1}{2}T_m^{min})$

3) If DT > TUB-TRLSE
DT=(TUB-TRLSE)/40

important Courant number as .9 is less than 1/2 T_{min} and TUB - T_R. If so, this DT is used. Otherwise, we set DT = (TUB - T_R)/40. Sample Problems 5A, B and C can be attempted now.

DVM /STC

New Right Hand Page

Notebook Divider Should Read: NWFT/DVM Sample Problems.

NWFT/DVM SAMPLE PROBLEMS

Five sample problems are presented, having as their main purpose illustration of the input mechanics and applicability of NWFT/DVM. As will be seen, much of the input data remains unchanged from problem to problem. Therefore, sample problem 1 represents a basic setup which is examined in some detail. This setup, referred to as the base-case (BC) is specific to the geometry of the reference site (Figure 1-SP) and uses results from the SWIFT computer code simulation of that site (Figure 2-SP).

We superimpose the NWFT/DVM flow network with the darker lines as depicted in Figure 3. Figure 4 shows the numbering system used by NWFT/DVM. Observe that legs 1-4 of the network are placed at the shale/middle sandstone interface and legs 5-8 lie at the shale/lower sandstone interface. The left-hand boundary of the network is taken as the midpoint of Column 29 (Figure 3) in order to satisfy two restrictions. First, it is at sufficient distance down-dip from the recharge region to ensure that the fluid flow has an insignificant vertical component. Second, it is far enough up-dip from the depository to ensure that most disruptive features near the depository will not affect the pressure boundary conditions. The resulting placement of the NWFT/DVM network is critical to the determination of input pressures, elevations, leg lengths, etc.

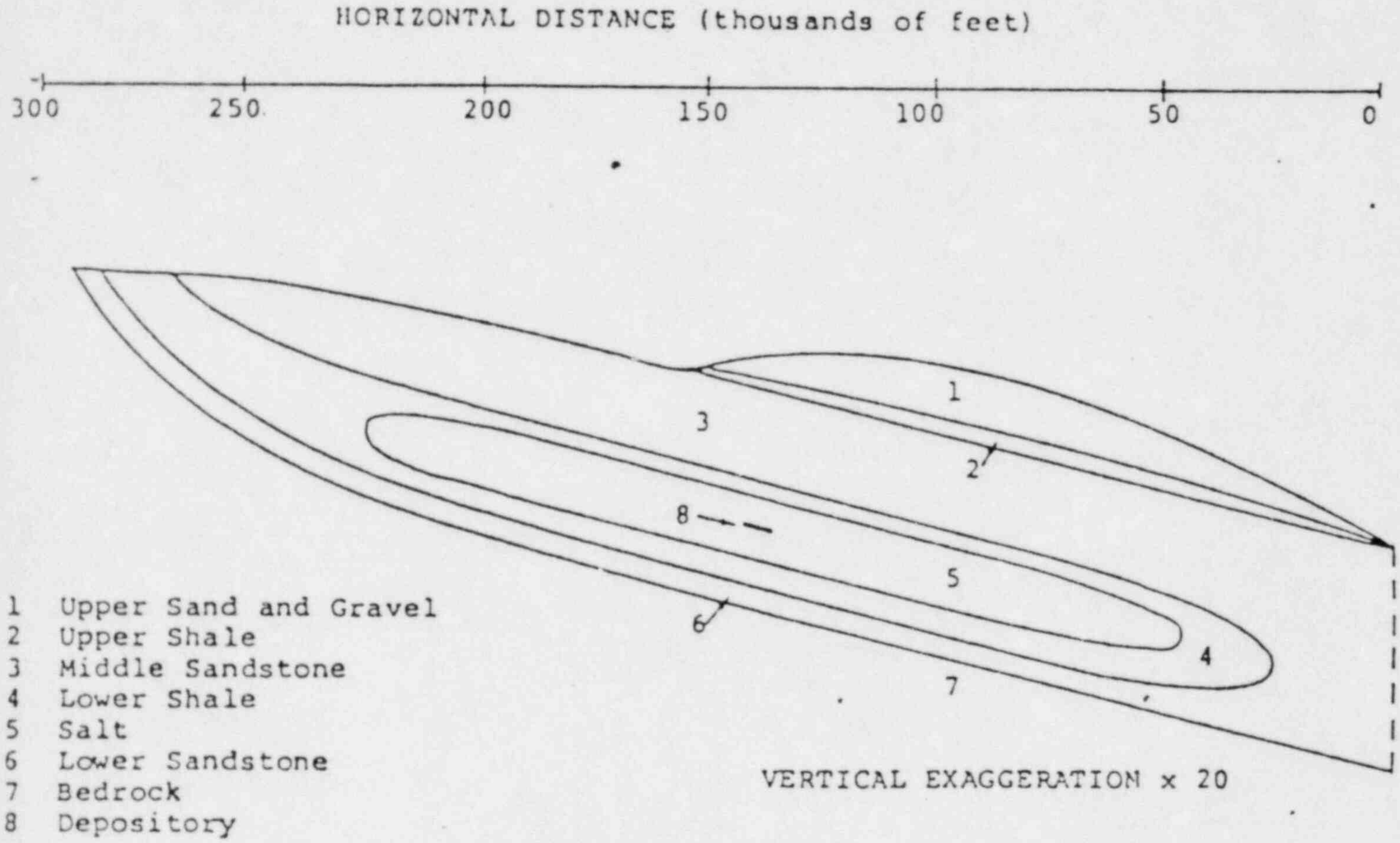


Figure 1-SP. The Reference Site Geology.

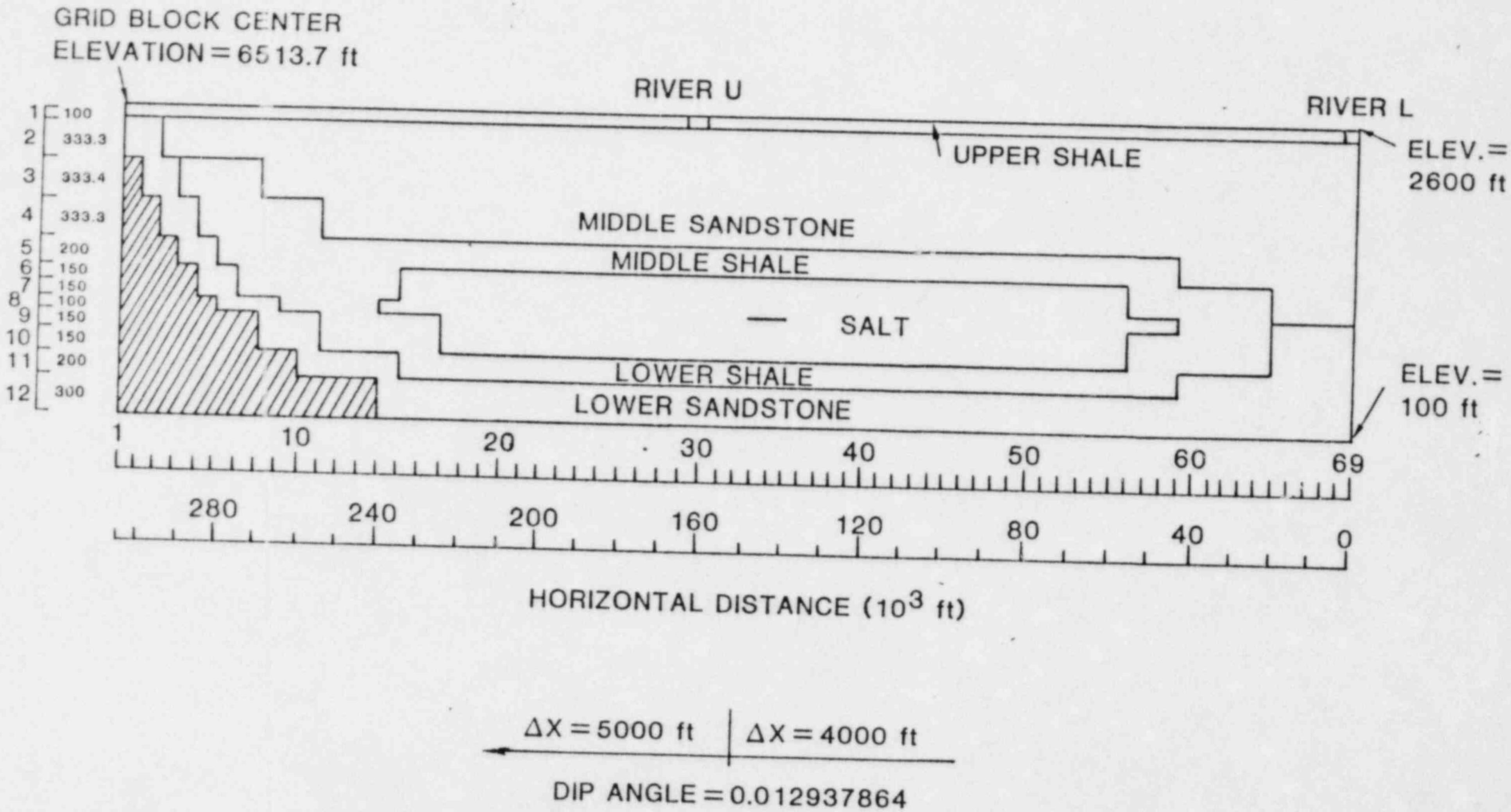
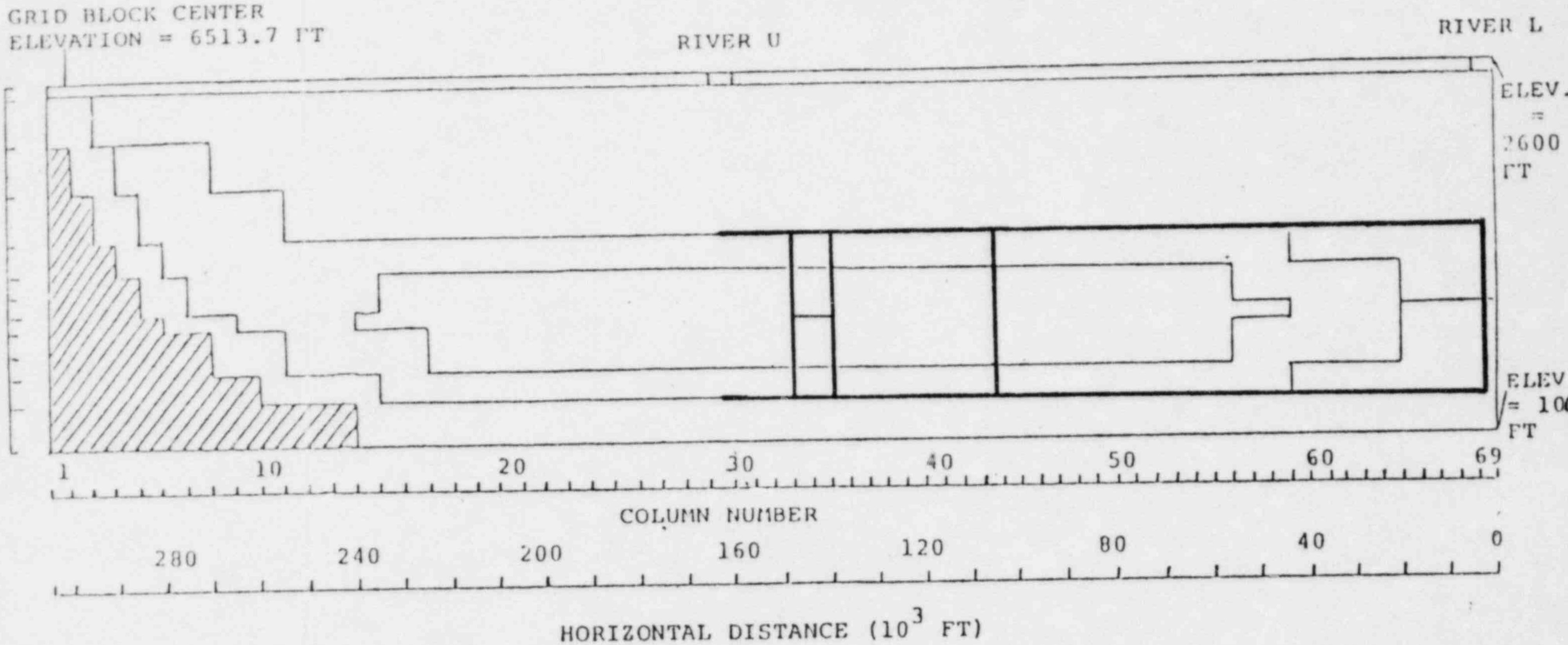


Figure 2-SP. SWIFT Setup for Reference Site



1	100
2	333.3
3	333.4
4	333.3
5	200
6	150
7	150
8	100
9	150
10	150
11	200
12	300

Figure 3-SP. NWFT Network - Dark Lines Indicate NWFT Legs

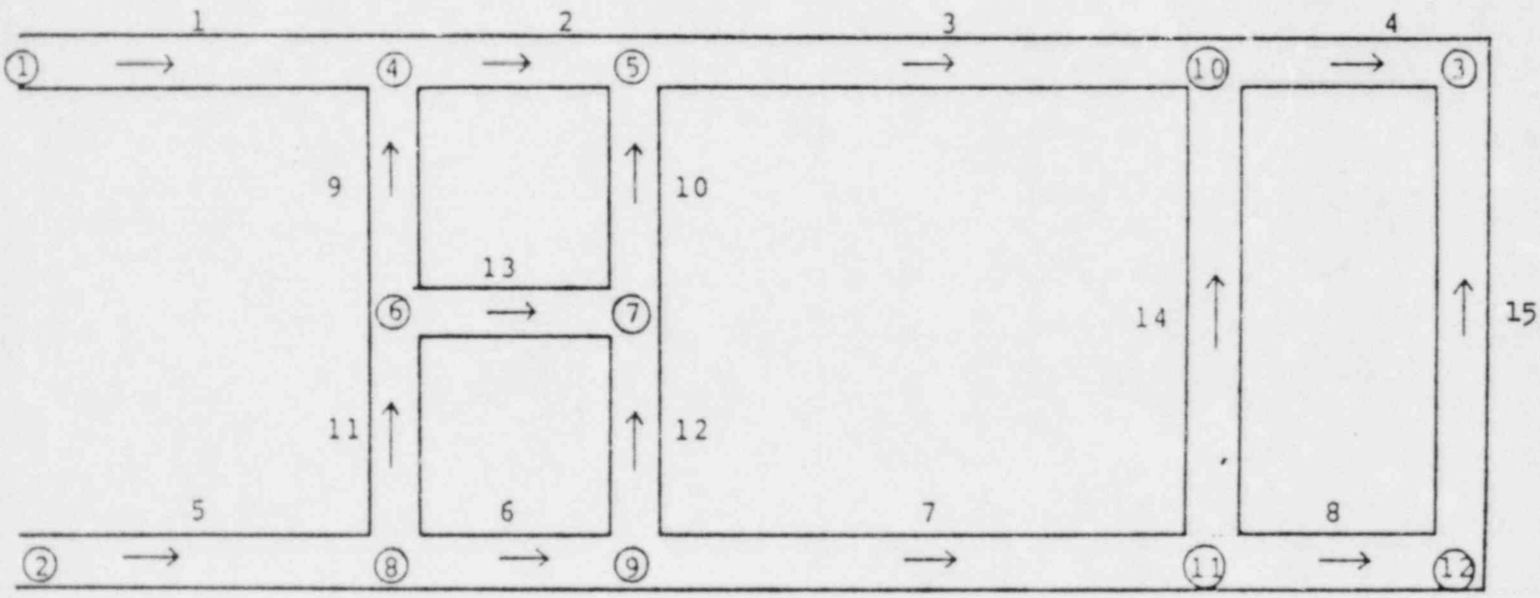


Figure 4-SP. NWFT/DVM Numbering System

DVM / STC

New Right Hand Page

NOTEBOOK DIVIDER SHOULD READ: S.P. 1 - Base Case

Sample Problem 1: Base Case

The base-case description is as follows:

BC(1) The title card (8A10)

BASECASE SETUP

BC(2) The options card (23I1)

Enter ones in column 1, 13 and 17.

BC(3) The pressures card (3E10.3)

Pressures at elevation for junctions 1, 2, and 3 are required boundary conditions. They are taken from the output of the comparable SWIFT base-case (i.e., no disruptions) simulation of the reference site. (See NWFT/DVM User's Manual NUREG/CR-2081.) SWIFT calculates pressures (lbs/in.^{2}) at the top center of each grid block. So, junction 1 corresponds to block (5, 29) and junction 2 to block (12, 29). These values can be found in Table 1-SP. Junction 3 is treated somewhat differently. By referring to Table 1-SP it can be seen that pressures along row 5 show little change from columns 29 through 65. From 66 to 69, however, pressures increase in order to drive the flow upward to river L. The discharge point in NWFT/DVM is technically 1100 feet below river L so there is no need for the pressure increase. Indeed, NWFT/DVM flow calculations are more compatible with those of SWIFT when the input outlet pressure is comparable to the typical row 5 entry. We therefore equate junction 3 pressure to that of junction 1. Thus,

P(1) = 432.7

P(2) = 646.1

P(3) = 432.7

SWIFT Base Case

, Table 1-SP: Pressure At Elevation H(PSI)

	1	2	3	4	5	6	7	8	9	10
1	-449.0	-425.5	-401.4	-371.6	-345.0	-322.0	-302.4	-286.1	-264.4	-245.8
2	-405.9	-382.4	-358.5	-328.8	-302.2	-279.2	-259.5	-243.0	-221.7	-202.7
3	-266.5	-238.5	-215.3	-194.0	-169.0	-146.3	-129.5	-99.9	-78.1	-58.8
4	-125.8	-99.5	-71.6	-59.3	-46.6	-24.2	-13.9	15.6	38.1	57.1
5	15.9	40.6	56.6	84.6	86.2	102.8	106.8	114.2	137.5	194.7
6	100.9	125.0	140.7	144.6	172.6	182.9	177.8	170.7	194.8	209.9
7	164.7	188.3	204.0	209.4	237.4	247.7	229.2	209.5	234.7	247.6
8	228.8	252.1	267.8	274.5	284.5	312.5	287.1	261.2	278.9	289.4
9	271.3	294.4	310.1	317.8	327.9	349.6	276.3	304.3	313.9	323.3
10	335.5	358.4	374.2	382.8	392.6	406.5	341.2	369.2	378.9	388.2
11	399.8	422.5	438.4	447.7	457.1	465.2	413.6	432.6	424.9	452.9
12	485.9	508.5	524.4	534.2	543.2	547.0	505.9	517.6	514.4	537.9

	11	12	13	14	15	16	17	18	19	20
1	-226.7	-207.8	-187.9	-170.7	-153.0	-138.1	-122.8	-110.4	-97.5	-87.4
2	-184.0	-164.7	-145.2	-127.7	-110.3	-95.1	-80.1	-67.3	-54.8	-44.3
3	-40.8	-21.0	-1.6	16.2	33.4	48.8	63.5	76.6	88.9	99.6
4	102.2	123.0	142.4	160.4	177.4	193.0	207.6	220.7	233.0	243.7
5	225.1	244.3	262.1	303.3	321.6	337.2	351.9	365.0	377.2	388.0
6	275.1	290.9	305.4	388.0	360.9	374.4	408.6	421.7	433.5	443.9
7	309.2	321.5	332.7	451.8	330.5	340.4	414.0	427.0	437.8	447.5
8	348.7	357.9	365.5	395.7	313.8	322.5	429.8	442.3	452.2	461.3
9	366.9	372.5	376.5	318.1	324.3	332.4	424.4	435.9	443.0	453.5
10	402.2	403.3	403.3	382.2	389.1	397.1	432.3	441.2	449.3	457.2
11	452.3	451.1	449.2	446.5	454.0	461.6	468.8	476.4	483.9	491.5
12	538.7	535.4	504.8	532.8	540.4	547.9	555.5	563.0	570.5	578.1

	21	22	23	24	25	26	27	28	29	30
1	-76.9	-69.1	-61.0	-55.7	-50.0	-47.0	-43.7	-43.0	-43.0	-43.4
2	-34.2	-26.1	-18.3	-12.6	-7.3	-4.0	-1.0	.0	.1	-.4
3	109.5	117.9	125.4	131.3	136.4	140.0	142.8	143.9	144.1	143.8
4	253.6	262.0	269.5	275.5	280.5	284.2	286.8	288.1	288.4	288.1
5	397.3	406.3	413.8	419.8	424.8	428.5	431.1	432.4	432.7	432.4
6	453.5	461.9	469.3	475.5	480.8	484.9	488.1	490.0	491.1	491.6
7	456.5	464.8	472.2	478.7	484.6	489.5	493.8	497.0	499.7	501.7
8	470.0	478.0	485.5	492.3	498.6	504.2	509.3	513.7	517.7	521.0
9	461.8	469.7	477.2	484.2	491.0	497.3	503.3	508.8	514.0	518.6
10	465.0	472.6	480.2	487.5	494.8	502.0	509.0	515.9	522.6	528.7
11	499.3	506.6	514.1	521.7	529.2	536.8	544.3	551.9	559.4	566.2
12	585.6	593.2	600.7	608.3	615.8	623.4	631.0	638.5	646.1	652.9

	31	32	33	34	35	36	37	38	39	40
1	-43.5	-43.6	-43.7	-43.8	-43.9	-44.0	-44.2	-44.3	-44.4	-44.5
2	-.7	-1.0	-1.3	-1.6	-2.0	-2.3	-2.6	-3.0	-3.3	-3.7
3	143.5	143.2	142.9	142.6	142.2	141.9	141.6	141.2	140.9	140.5
4	287.0	287.5	287.2	286.9	286.6	286.2	285.9	285.6	285.2	284.8
5	432.[illegible]	431.8	431.5	431.2	430.9	430.6	430.2	429.9	429.5	429.1
6	492.0	492.4	492.7	493.1	493.5	493.8	494.2	494.5	494.8	495.1
7	533.4	505.2	506.9	508.6	510.4	512.1	513.8	515.5	517.2	518.9
8	523.8	526.7	529.6	532.4	535.3	538.2	541.0	543.9	546.7	549.6
9	522.6	526.6	530.6	534.6	538.6	542.6	546.6	550.6	554.6	558.6
10	534.1	539.4	544.8	550.2	555.5	560.9	566.3	571.6	577.0	582.4
11	572.5	578.3	584.4	590.4	596.5	602.5	608.6	614.7	620.7	626.8
12	658.9	665.0	671.0	677.1	683.2	689.2	695.3	701,3	707.4	713.5

Table 1-SP (cont'd)

	41	42	43	44	45	46	47	48	49	50
1	-44.6	-44.8	-44.9	-45.1	-45.2	-45.4	-45.5	-45.7	-45.9	-46.1
2	-4.1	-4.5	-4.9	-5.3	-5.8	-6.3	-6.8	-7.3	-7.8	-8.4
3	140.1	139.7	139.3	138.9	138.4	137.9	137.4	136.9	136.4	135.8
4	284.4	284.0	283.6	283.2	282.7	282.3	281.8	281.2	280.7	280.1
5	428.8	428.4	427.9	427.5	427.1	426.6	426.1	425.5	425.0	424.4
6	495.5	495.8	496.0	496.3	496.5	496.8	497.0	497.1	497.3	497.4
7	520.6	522.3	524.0	525.6	527.2	528.9	530.5	532.1	533.6	535.2
8	552.4	555.2	558.1	560.9	563.7	566.5	569.3	572.0	574.8	577.5
9	562.6	566.5	570.5	574.5	578.5	582.4	586.4	590.3	594.3	598.2
10	587.8	593.1	598.5	603.9	609.2	614.6	619.9	625.3	630.7	636.0
11	632.8	638.9	645.0	651.0	657.1	663.2	669.2	675.3	681.4	687.4
12	719.5	725.6	731.6	737.7	743.8	749.9	755.9	762.0	768.1	774.1

	51	52	53	54	55	56	57	58	59	60
1	-46.3	-46.5	-46.8	-47.0	-47.3	-47.5	-47.8	-48.1	-48.2	-47.6
2	-9.1	-9.7	-10.4	-11.2	-11.9	-12.8	-13.6	-14.4	-14.8	-12.9
3	135.1	134.5	133.8	133.0	132.2	131.4	130.5	129.6	128.8	131.1
4	279.4	278.8	278.1	277.3	276.6	275.7	274.8	273.7	271.8	275.0
5	423.8	423.1	422.4	421.7	420.9	419.6	419.0	417.4	414.1	419.1
6	497.5	497.6	497.6	497.6	497.4	505.3	505.4	503.5	494.2	499.9
7	536.7	538.2	539.7	541.1	542.4	569.9	570.3	568.1	546.0	553.2
8	580.3	583.0	585.7	588.3	590.4	592.4	596.1	598.3	599.7	608.5
9	602.1	606.0	609.9	613.8	616.7	593.2	600.2	607.0	631.8	642.1
10	641.4	646.7	652.1	657.4	662.3	658.3	665.1	671.6	683.6	695.4
11	693.5	699.6	705.7	711.7	717.8	723.7	730.0	736.1	742.0	754.6
12	780.2	786.3	792.4	798.5	804.5	810.6	816.7	822.8	828.9	841.4

	61	62	63	64	65	66	67	68	69
1	-46.7	-45.8	-44.8	-43.8	-42.5	-40.3	-38.0	-36.3	-38.2
2	-15.3	-7.5	-4.7	-1.6	2.3	8.8	16.0	20.9	15.2
3	133.8	136.6	139.5	142.4	145.9	152.9	160.8	167.8	172.8
4	278.0	280.9	283.7	286.4	288.8	296.8	306.0	315.4	326.2
5	422.3	425.2	428.0	430.5	430.9	440.7	451.0	462.0	475.5
6	504.1	508.0	511.8	515.0	515.3	526.9	538.0	549.9	564.8
7	559.4	565.4	571.2	576.2	578.9	591.6	603.3	615.9	631.6
8	616.3	624.0	631.6	638.3	643.4	656.5	668.5	681.3	697.4
9	651.6	661.0	670.3	678.9	686.6	699.8	711.9	724.8	741.0
10	706.9	718.4	729.7	740.8	751.6	764.8	776.9	790.0	806.3
11	767.1	779.6	792.0	804.4	816.7	829.9	842.0	855.1	871.5
12	853.9	866.3	878.7	891.1	903.5	916.6	928.8	942.0	958.5

BC(4) The Conductivity Cards (8E10.3, 7E10.3)

The reference site hydraulic properties used in the SWIFT calculations are shown in Table 2. Appropriate hydraulic conductivities for legs 1, 2, 3 and 4 are the horizontal conductivity of the middle sandstone. The horizontal conductivity of the lower sandstone is used for legs 5, 6, 7, and 8. As the hydraulic conductivity across the salt and shale is essentially vertical, we assign an effective vertical conductivity of salt and shale to legs 9, 10, 11, 12, and 14. Similarly leg 15 represents vertical flow through portions of both the middle and lower sandstone. The differing media can be viewed as providing resistance to flow in series. As an example we find the effective conductivity of leg 15, thus

$$\bar{R} = R_L + R_m$$

where

$\bar{R}$ = total resistance to be assigned leg 15.

R_L = resistance of lower sandstone.

R_M = resistance of middle sandstone.

So

$$\frac{L_{15}}{K_{15} \quad A_{15}} = \frac{L_L}{K_L \quad A_L} + \frac{L_m}{K_m \quad A_m}$$

Table 2-SP. Reference Site Hydraulic Properties

	Horizontal Hydraulic Conductivity (ft/day)	Vertical Hydraulic Conductivity (ft/day)	Porosity
Middle Sandstone	50	1.4	0.3
Lower Shale	10^{-2}	10^{-3}	0.3
Salt	10^{-5}	10^{-6}	0.03
Lower Sandstone	40	7.0	0.3

where

L_{15} = length of leg 15

K_{15} = conductivity assigned leg 15

A_{15} = cross-sectional area of leg 15

L_L = length of leg 15 through lower sandstone

K_L = vertical hydraulic conductivity of lower sandstone

L_m = length of leg 15 through middle sandstone

K_m = vertical hydraulic conductivity of middle sandstone

A_L = $A_m = A_{15}$

From Figure 3-SP and Table 2-SP

$$\frac{1100}{K_{15}} = \frac{600}{7} + \frac{500}{1.4}$$

In a similar manner effective conductivities are found for legs 9-12 and 14. The appropriate leg lengths are given in the BC(6) cards below. Refer to Table 2-SP for the vertical salt/shale conductivities. The horizontal conductivity of salt is assigned to the depository location, leg 13. So,

legs 1-4	K = 50 ft/day
legs 5-8	K = 40 ft/day
legs 9 & 12	$K = 1.5 \times 10^{-6}$ ft/day
legs 10 & 11	$K = 1.67 \times 10^{-6}$ ft/day
leg 13	$K = 10^{-5}$ ft/day
leg 14	$K = 1.57 \times 10^{-6}$ ft/day
leg 15	K = 2.5 ft/day

BC(5) The Cross-sectional Area Cards (8E10.3, 7E10.3)

The aquifer widths are assumed to be that of the depository (6000 ft). Upper and lower aquifer thicknesses are 1000 ft and 300 ft, respectively. From Figure 3-SP the width of a leg 15 is 20000 ft. The interior legs are arbitrarily assigned to have areas of 1 ft^2. So,

legs 1-4	area = $1000 \times 6000 = 6 \times 10^6$ ft^2
legs 5-8	area = $300 \times 6000 = 1.8 \times 10^6$ ft^2
legs 9-14	area = 1 ft^2
leg 15	area = $20000 \times 6000 = 1.2 \times 10^8$ ft^2

BC(6) The Leg Length Cards (8E10.3, 7E10.3)

As SWIFT pressures are located at grid block midpoints, leg lengths are measured accordingly. From the right edge of the depository to the river midpoint is 138,000 ft. Depository length is 8000 ft and is assumed to be level. From the left edge of the depository to the NWFT/DVM aquifer inlets is 14,500 ft. Vertical legs must maintain a total length of 1100 ft. Leg 14 is arbitrarily placed 38,000 ft down-dip from legs 10 and 12. So,

	Leg Length (ft)
legs 1 & 5	14,500
legs 2, 6 & 13	8,000
legs 3 & 7	38,000
legs 4 & 8	100,000
leg 9	600
leg 10	497
leg 11	500
leg 12	603
legs 14 & 15	1,100

BC(7) The Junction Elevation Cards (8E10.3, 4E10,3)

The sine of the dip angle used in SWIFT is .012937864. Using the top center of the grid blocks as measuring points, the distance from block (1,1) to (29,1) is 140,000 ft. Sin e grid block (1,1) has elevation 6513.7 ft, the elevation of block (29,1) is

$$6513.7 - (140000)(.012937864) = 4702.41$$

The elevation of junction 1 (the upper aquifer inlet) is therefore,

$$4702.41 - 1100 = 3602.41$$

With this as a reference point the leg lengths and dip angle are used to determine the remaining junction elevations.

Junction Number	Junction Elevation (ft)
2	2502.41
3	1525.81
4	3414.81
5	3311.81
6	2814.81
7	2814.81
8	2314.81
9	2211.31
10	2819.67
11	1719.67
12	425.89

BC(8) The Porosity Cards (8E10.3, 7E10.3)

Legs 1-8 and 15 are taken from the values for sandstone in Table 2-SP. Legs 9-14 are assigned salt porosity. So,

legs 1-8, 15	$\phi = .3$
legs 9-14	$\phi = .03$

BC(9) The Brine Concentration Cards (8E10.3, 7E10.3)

The interior legs are assumed to contain saturated brine and the aquifer legs are assumed to have fresh water. So,

legs 1-8, 15	brine concentration = 0
legs 9-14	brine concentration = 1

BC(10) The Migration Path Card (8I5)

Even though there are no disruptive features in the basecase, the 6 legs (13, 11, 6, 7, 8, and 15) provide an avenue for radionuclide migration. Discharge does not occur before 10^6 years, but nevertheless, NWFT/DVM requires that a path be read. So enter

6 13 11 6 7 8 15

BC(11) The Well Information Card (I5, 2E10.0)

This card is read only if withdrawal wells are present signified by setting IOPT(12) ≠ 0. So, it is omitted in the base case.

BC(12) The Isotope Data Cards

The decay chain

NP 237 → U233 → TH229

is used in the base-case because it is transported in sample problems 2 and 3. The complete set of isotope data is contained in the following 6 lines:

(i)	3	(I5)
(ii)	237., NP237, 1, 0, 2.14E6, 1.E3	(E10.0, 4x, A6, 2I10, 2E)0.
(iii)	233., U233, 2, 1, 1.62E5, 1.E3	(E10.0, 4x, A6, 2I10,2E) 0.
(iv)	1, 1.	(I10, E10.0)
(v)	229., TH229, 3, 1, 7.3E3, 1.E3	(E10.0, 4x, A6, 2I10,2E)10.
(vi)	2, 1.	(I10, E10.0)

Line (i) indicates the number of isotopes (NOISO) in the decay chain. Lines (ii), (iii), and (v) contain the atomic mass, name, component number, the number of parents, the half-life, and the initial number of curies for each isotope. Lines (iv) and (vi) are the parent information cards for U233 and TH229, respectively. They give the parent component number and parent-to-daughter decay fraction. For example, line (iv) indicates that U233 has the parent NP237 (component 1) and that NP237 decays only to U233 (decay fraction = 1.).

BC(13) The Distribution Coefficients (KD) Cards

A total of NOISO (=3) cards are required. Here, 3 blank cards are input. Since the machine considers blanks as zeros, all radionuclide velocities are therefore unretarded.

BC(14) Leach Time and Dispersivity Card (2E10.3)

Leach time is set to 10^5 years and dispersivity to 500 ft. Cards 15-17 are skipped because IOPT(13) = 1 indicates that an analytic solution will be used.

BC(15) The DVM Control Card

Disregard in the base-case

BC(16) Solubility Limit Card(s)

Disregard in the base-case.

BC(17) Time-dependent Mass Fraction Cards

Disregard in the base-case.

BC(18) The vector/time Card

Insert a blank card. In particular, this signifies an upper bound time of 10^6 years and a release time of zero years are to be used.

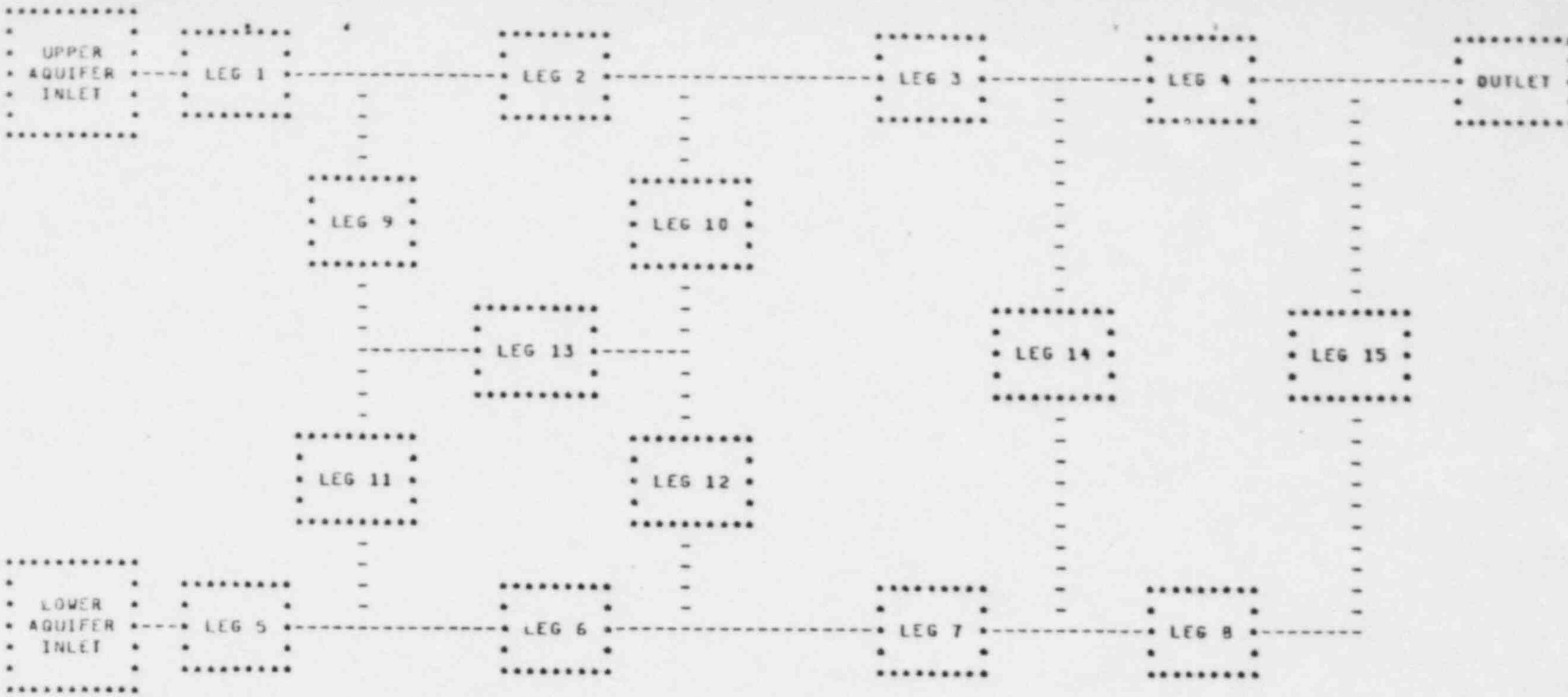
Table 3-SP is a list of the Base Case Input. Table 4-SP contains the Base Case Output.

```
                     THE BASECASE SETUP                                                                    BC  2
1                1   1                                                                                     BC  3
  432.70     646.10     432.70                 40.0        40.0        40.0        40.0                    BC  4
    50.0       50.0       50.0       50.0                                                                  BC  4
  1.5E-6    1.67E-6    1.67E-6     1.5E-6     1.E-5     1.57E-6         2.5                                BC  5
    6.E6       6.E6       6.E6       6.E6     1.8E6       1.8E6       1.8E6       1.8E6                    BC  5
      1.        1.0         1.        1.0        1.          1.       1.2E8                                BC  6
  14500.      8000.     38000.    100000.    14500.       8000.      38000.     100000.                    BC  6
    600.      496.5       500.      603.5     8000.       1100.       1100.                                BC  7
 3602.44    2502.41    1525.89    3414.81   3311.31     2814.81     2814.81     2314.81                    BC  7
 2211.31    2819.67    1719.67     425.89                                                                  BC  8
      .3         .3         .3         .3        .3          .3          .3          .3                    BC  8
     .03        .03        .03        .03       .03         .03          .3                                BC  9
      0.         0.         0.         0.        0.          0.          0.          0.                    BC  9
      1.         1.         1.         1.        1.          1.          0.                                BC 10
 6    13     11    6     7     8     15                                                                    BC 12
 3                                                                                                         BC 12
    237.      NP237          1          0    2.14E6        1.E3                                            BC 12
    233.       U233          2          1    1.62E5        1.E3                                            BC 12
       1         1.                                                                                        BC 12
    229.      TH229          3          1     7.3E3        1.E3                                            BC 12
       2         1.                                                                                        BC 13
                                                                                                           BC 13
                                                                                                           BC 13
                                                                                                           BC 14
    1.E5       500.                                                                                        BC 18
```

Table 3-SP. NWFT/DVM Base Case Input

```
THE BASECASE SETUP

OPTIONS 1.1  2,0  3,0  4,0  5,0  6,0  7,0  8,0  9,0 10,0 11,0 12,0 13,1 14,0 15,0 16,0 17,1 18,0 19,0 20,0 21,0 22,0 23,0

NUMBER OF ISOTOPES     3

    ISOTOPE NAME            HALF LIFE (YEARS)      INITIAL AMOUNT (CI)

       NP237                    2.140E+06               1.000E+03
        U233                    1.620E+05               1.000E+03
       TH229                    7.300E+03               1.000E+03

    LEACH TIME =     1.000E+05 YEARS      DISPERSIVITY =    5.000E+02 FEET

NO OF VECTORS =    0 TIME UPPER BOUND =         1.00E+06
```

Table 4-SP. Base Case Output



------RADIONUCLIDE MIGRATION PATH------LEGS 13 11 6 7 8 15

UPPER AQUIFER INLET
INLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 3602.41 FT

LOWER AQUIFER INLET
INLET PRESSURE = 93038.40 LB/FT**2
ELEVATION = 2502.41 FT

OUTLET
OUTLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 1525.89 FT

ELEVATIONS OF OTHER POINTS
JUNCTION 4 (LEGS 1-2-9) = 3414.81 FT
JUNCTION 5 (LEGS 2-3-10) = 3311.31 FT
JUNCTION 6 (LEGS 9-11-13) = 2814.81 FT
JUNCTION 7 (LEGS 10-12-13) = 2814.81 FT
JUNCTION 8 (LEGS 5-6-11) = 2314.81 FT
JUNCTION 9 (LEGS 6-7-12) = 2211.31 FT
JUNCTION10 (LEGS 3-4-14) = 2819.67 FT
JUNCTION11 (LEGS 7-8-14) = 1719.67 FT
JUNCTION12 (LEGS 8-15) = 425.89 FT

LEG PROPERTIES

LEG 1
****
LENGTH = 1.45E+04 FT
AREA = 6.00E+06 FT**2

Table 4-SP. (cont'd) B ,e Case Output

```
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

               LEG PROPERTIES

LEG  2
********
               LENGTH =  8.00E+03 FT
                 AREA =  6.00E+06 FT**2
         CONDUCTIVITY =  1.83E+04 FT/YR
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

               LEG PROPERTIES

LEG  3
********
               LENGTH =  3.80E+04 FT
                 AREA =  6.00E+06 FT**2
         CONDUCTIVITY =  1.83E+04 FT/YR
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

               LEG PROPERTIES

LEG  4
********
               LENGTH =  1.00E+05 FT
                 AREA =  6.00E+06 FT**2
         CONDUCTIVITY =  1.83E+04 FT/YR
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

               LEG PROPERTIES

LEG  5
********
               LENGTH =  1.45E+04 FT
                 AREA =  1.80E+06 FT**2
         CONDUCTIVITY =  1.46E+04 FT/YR
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

               LEG PROPERTIES

LEG  6
********
               LENGTH =  8.00E+03 FT
                 AREA =  1.80E+06 FT**2
         CONDUCTIVITY =  1.46E+04 FT/YR
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

               LEG PROPERTIES

LEG  7
********
               LENGTH =  3.80E+04 FT
                 AREA =  1.80E+06 FT**2
         CONDUCTIVITY =  1.46E+04 FT/YR
             POROSITY =    .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP
```

Table 4-SP (cont'd) Base Case Output

LEG 8
....

LENGTH = 1.00E+05 FT
AREA = 1.80E+06 FT**2
CONDUCTIVITY = 1.46E+04 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

LEG PROPERTIES

LEG 9
....

LENGTH = 6.00E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.48E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 10
....

LENGTH = 4.97E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 6.10E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 11
....

LENGTH = 5.00E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 6.10E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 12
....

LENGTH = 6.04E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.48E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 13
....

LENGTH = 8.00E+03 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 3.65E-03 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 14
....

LENGTH = 1.10E+03 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.73E-04 FT/YR
POROSITY = .0300

Table 4-SP. (cont'd) Base Case Output

FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 15
****

LENGTH = 1.10E+03 FT
AREA = 1.20E+08 FT**2
CONDUCTIVITY = 9.13E+02 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

DISTRIBUTION COEFFICIENTS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	0.	0.	0.
LEG11	0.	0.	0.
LEG 6	0.	0.	0.
LEG 7	0.	0.	0.
LEG 8	0.	0.	0.
LEG15	0.	0.	0.

RETARDATION FACTORS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	.10000E+01	.10000E+01	.10000E+01
LEG11	.10000E+01	.10000E+01	.10000E+01
LEG 6	.10000E+01	.10000E+01	.10000E+01
LEG 7	.10000E+01	.10000E+01	.10000E+01
LEG 8	.10000E+01	.10000E+01	.10000E+01
LEG15	.10000E+01	.10000E+01	.10000E+01

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PRESSURES AT THE LEG JUNCTIONS

AT JUNCTION 1 = 6.2309E+04 LB/FT**2
AT JUNCTION 2 = 9.3038E+04 LB/FT**2
AT JUNCTION 3 = 6.2309E+04 LB/FT**2
AT JUNCTION 4 = 6.2309E+04 LB/FT**2
AT JUNCTION 5 = 6.2309E+04 LB/FT**2
AT JUNCTION 6 = 7.9704E+04 LB/FT**2
AT JUNCTION 7 = 7.9767E+04 LB/FT**2
AT JUNCTION 8 = 9.6469E+04 LB/FT**2
AT JUNCTION 9 = 9.8362E+04 LB/FT**2
AT JUNCTION 10 = 6.2309E+04 LB/FT**2
AT JUNCTION 11 = 1.0735E+05 LB/FT**2
AT JUNCTION 12 = 1.3101E+05 LB/FT**2

LEG NO.	FLOW VOL. (CU FT)/DAY	DARCY VEL. FT/DAY	PORE VEL. FT/DAY
1	3.88E+06	6.47E-01	2.16E+00
2	3.88E+06	6.47E-01	2.16E+00
3	3.88E+06	6.47E-01	2.16E+00
4	3.88E+06	6.47E-01	2.16E+00
5	6.58E+05	3.66E-01	1.22E+00
6	6.58E+05	3.66E-01	1.22E+00
7	6.58E+05	3.66E-01	1.22E+00
8	6.58E+05	3.66E-01	1.22E+00
9	-7.59E-07	-7.59E-07	-2.53E-05
10	-7.29E-07	-7.29E-07	-2.43E-05

Table 4-SP. (cont'd) Base Case Output

11	-7.60E-07	-7.60E-07	-2.53E-05
12	-7.28E-07	-7.28E-07	-2.43E-05
13	-8.80E-10	-8.80E-10	-2.93E-08
14	-5.83E-07	-5.83E-07	-1.94E-05
15	6.58E+05	5.48E-03	1.83E-02

TOTAL PATH LENGTH (FT) = 1.5160E+05
FROM DEPOSITORY MIDPT (FT) = 1.5160E+05
AVERAGE FLUID VELOCITY (FT/Y) = 4.0570E-04
NIP IS REDUCED TO 1 SINCE DISCHARGE EQUALS 0 THROUGH YEAR 1.0000000E+06

Table 4-SP. (cont'd) Base Case Output

DVM / STC

New Right Hand Page

Notebook Divider Should Read: S.P. 2- DVM and Anal Transp Options

Sample Problem 2: DVM and Analytical Model Options

Problem 2 is designed to demonstrate the use of both the DVM and analytic model options, the use of recurrent data sets, and the ability of DVM to reproduce the analytic model output. Leach-limited source terms and equal distribution coefficients are used as they are required by the analytic model.

A U-Tube breachment senario is simulated. Leg 9 represents a 30 ft diameter shaft and leg 10 a 13.5 inch diameter borehole. Flow occurs down leg 9, across leg 13, and up leg 10. The first data set is for execution of the analytic transport model option and the second for the DVM option.

The first set is the base-case with the following changes.

BC(1) A different title.

SAMPLE PROBLEM NO. 2

BC(2) Set options 1 and 17 to zero

BC(4) Conductivity in leg 9 is .1 ft/day to represent the shaft and 10 ft/day in leg 10 for the borehole. The depository (leg 13) is also assigned 10 ft/day.

BC(5) The cross-sectional area of leg 9 is set to 707 ft^2. that is,

$$\text{AREA } (9) = \pi r^2 = \pi (15)^2 = 707 \text{ ft}^2$$

Note that the cross-sectional area of leg 10 remains 1 ft^2.

Leg 13 is used to represent a corridor of cross-sectional area 30 ft x 18 ft.

BC(8) Porosity of legs 9 and 10 is arbitrarily set to .15. The porosity of leg 13 is set to 0.3 which would be reasonable for salt backfill in which no compaction has occurred.

BC(9) The brine concentration of leg 9 is determined by assuming that fresh water enters from the upper sandstone. Furthermore, the water is assumed to remain fresh through the 200 ft shale layer and to become saturated in the salt. Thus the brine concentration is estimated as (length of leg 9 in the salt layer)/(total length of leg 9) = 400/600 = 0.67. Legs 10 and 13 are assumed to contain saturated brine.

BC(10) The migration path now follows the 4 legs

13, 10, 3, 4.

BC(13) The upper aquifer legs 3 and 4, which are the 3rd and 4th legs in the migration path, are arbitrarily assigned the KD value 1.6 ft^3/lb for each isotope. Because of the salt in leg 13 and the presence of brine in both legs 10 and 13, no sorption is assumed for these legs.

The second data set contains only the following 3 cards.

The INP CARD (17I1)

A value of 1 is placed in columns 1 and 15 while the remaining columns are left blank. This signifies that the option card BC(2) and the DVM control card BC(15) are to be read.

BC(2) The option card has 3 changes. Ones are emplaced in columns 6 and 7 to delete repetitive printout and a zero is put in column 13 to indicate that the DVM option is to be used.

BC(15) Use a blank for the DVM control card.

BC(18) This card must be present at the end of each data set. A blank may be used here.

BC(18) This card must be present at the end of each data set. A blank may be used here.

Figure 5-SP displays the discharge rate curve for each isotope. The agreement of DVM to the analytic solution is excellent. Input data are given in TAble 5-SP, with output in Table 6-SP.

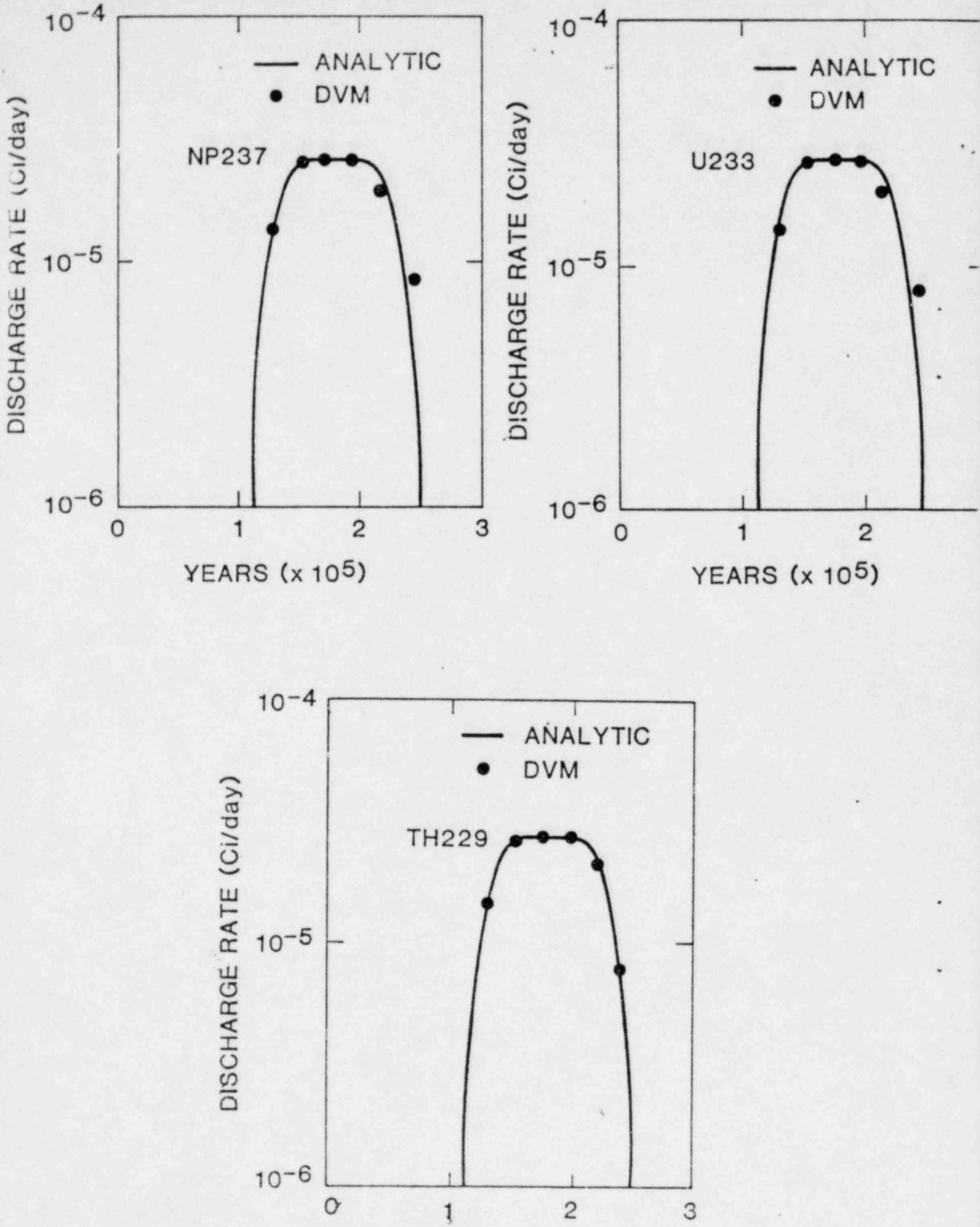


Figure 5-SP. Discharge Rate Curve for Each Isotope

Table 5-SP. Sample Problem 2 Input Data

```
            SAMPLE PROBLEM NO. 2                                                  BC   1
         1                                                                        BC   2
   432.70    646.10    432.70                                                     BC   3
     50.0      50.0      50.0      50.0      40.0      40.0      40.0      40.0   BC   4
       .1       10.  1.67E-6    1.5E-6       10.  1.57E-6       2.5              BC   4
     6.E6      6.E6      6.E6      6.E6     1.8E6     1.8E6     1.8E6     1.8E6   BC   5
     707.       1.0        1.       1.0      540.        1.     1.2E8             BC   5
   14500.     8000.    38000.   100000.    14500.     8000.    38000.   100000.   BC   6
     600.     496.5      500.     603.5     8000.     1100.     1100.             BC   6
  3602.41   2502.41   1525.89   3414.81   3311.31   2814.81   2814.81   2314.81   BC   7
  2211.31   2819.67   1719.67    425.89                                         BC   7
       .3        .3        .3        .3        .3        .3        .3        .3   BC   8
      .15       .15       .03       .03        .3       .03        .3             BC   8
       0.        0.        0.        0.        0.        0.        0.        0.   BC   9
      .67        1.        1.        1.        1.        1.        0.             BC   9
    4   13   10    3    4                                                         BC  10
    3                                                                             BC  12
     237.     NP237         1         0    2.14E6      1.E3                       BC  12
     233.      U233         2         1    1.62E5      1.E3                       BC  12
        1        1.                                                               BC  12
     229.     TH229         3         1     7.3E3      1.E3                       BC  12
        2        1.                                                               BC  12
                          1.6       1.6                                           BC  13
                          1.6       1.6                                           BC  13
                          1.6       1.6                                           BC  13
     1.E5      500.                                                               BC  14
                                                                                  BC  18
1                  1                                                              BC   0
         11                                                                       BC   2
                                                                                  BC  15
                                                                                  BC  18
```

SAMPLE PROBLEM NO. 2

OPTIONS 1,0 2,0 3,0 4,0 5,0 6,0 7,0 8,0 9,0 10,0 11,0 12,0 13,1 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0

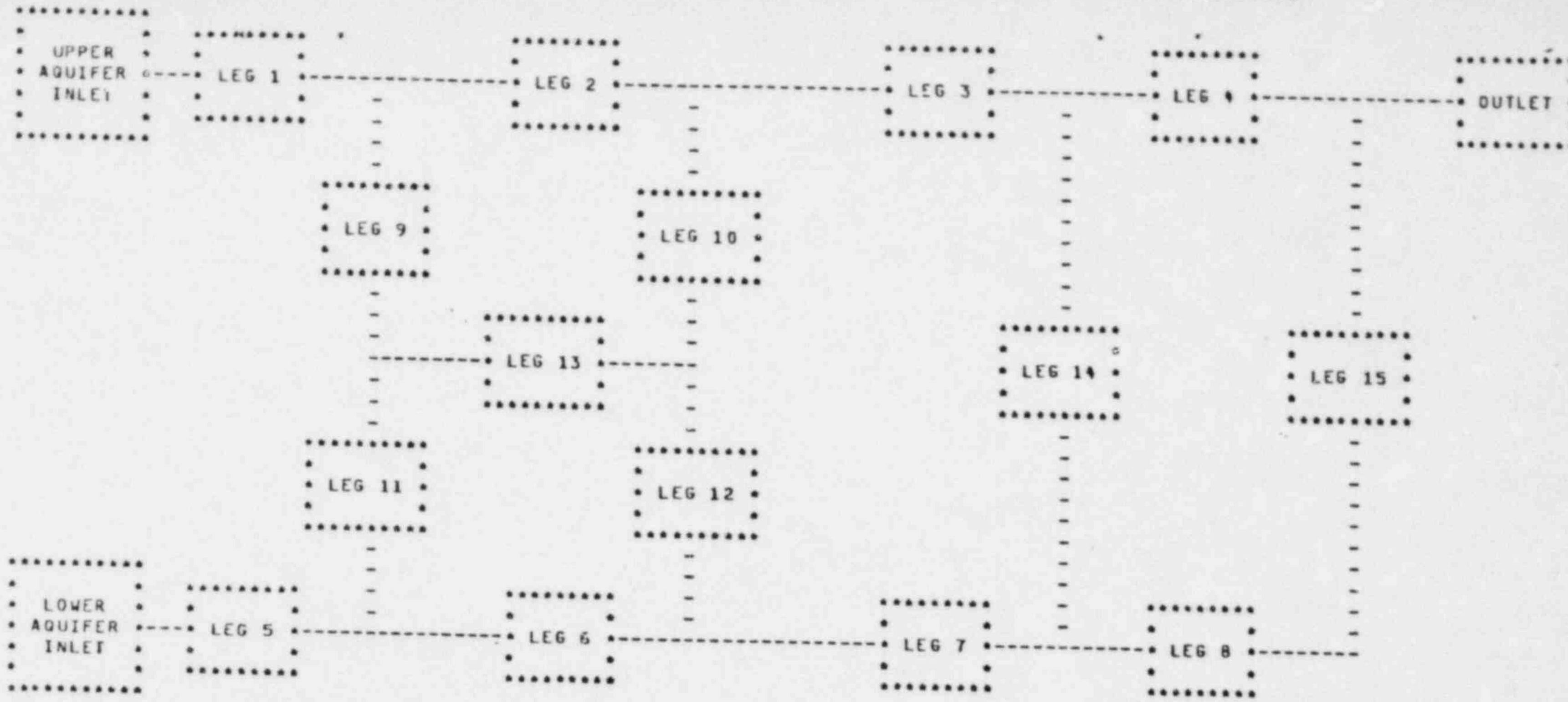
NUMBER OF ISOTOPES 3

ISOTOPE NAME	HALF LIFE (YEARS)	INITIAL AMOUNT (CI)
NP237	2.140E+06	1.000E+03
U233	1.620E+05	1.000E+03
TH229	7.300E+03	1.000E+03

LEACH TIME = 1.000E+05 YEARS DISPERSIVITY = 5.000E+02 FEET

NO OF VECTORS = 0 TIME UPPER BOUND = 1.00E+06

Table 6-SP Sample Problem 2 Output



------RADIONUCLIDE MIGRATION PATH------LEGS 13 10 3 4

UPPER AQUIFER INLET
INLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 3602.41 FT

LOWER AQUIFER INLET
INLET PRESSURE = 93038.40 LB/FT**2
ELEVATION = 2502.41 FT

OUTLET
OUTLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 1525.89 FT

ELEVATIONS OF OTHER POINTS

JUNCTION 4 (LEGS 1-2-9) =	3414.81 FT
JUNCTION 5 (LEGS 2-3-10) =	3311.31 FT
JUNCTION 6 (LEGS 9-11-13) =	2814.81 FT
JUNCTION 7 (LEGS 10-12-13) =	2814.81 FT
JUNCTION 8 (LEGS 5-6-11) =	2314.81 FT
JUNCTION 9 (LEGS 6-7-12) =	2211.31 FT
JUNCTION10 (LEGS 3-4-14) =	2819.67 FT
JUNCTION11 (LEGS 7-8-14) =	1719.67 FT
JUNCTION12 (LEGS 8-15) =	425.89 FT

LEG PROPERTIES

LEG 1
****
LENGTH = 1.45E+04 FT
AREA = 6.00E+06 FT**2

Table 6-SP (cont'd) Sample Problem 2 Output

```
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP

         LEG PROPERTIES

LEG  2
********
         LENGTH =  8.00E+03 FT
           AREA =  6.00E+06 FT**2
   CONDUCTIVITY =  1.83E+04 FT/YR
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP

         LEG PROPERTIES

LEG  3
********
         LENGTH =  3.80E+04 FT
           AREA =  6.00E+06 FT**2
   CONDUCTIVITY =  1.83E+04 FT/YR
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP

         LEG PROPERTIES

LEG  4
********
         LENGTH =  1.00E+05 FT
           AREA =  6.00E+06 FT**2
   CONDUCTIVITY =  1.83E+04 FT/YR
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP

         LEG PROPERTIES

LEG  5
********
         LENGTH =  1.45E+04 FT
           AREA =  1.80E+06 FT**2
   CONDUCTIVITY =  1.46E+04 FT/YR
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP

         LEG PROPERTIES

LEG  6
********
         LENGTH =  8.00E+03 FT
           AREA =  1.80E+06 FT**2
   CONDUCTIVITY =  1.46E+04 FT/YR
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP

         LEG PROPERTIES

LEG  7
********
         LENGTH =  3.80E+04 FT
           AREA =  1.80E+06 FT**2
   CONDUCTIVITY =  1.46E+04 FT/YR
       POROSITY =   .3000
   ROCK DENSITY =  1.19E+02 LB/FT**3
  FLUID DENSITY =  6.23E+01 LB/FT**3
FLUID VISCOSITY =  1.00E+00 CP
```

Table 6-SP. (cont'd) Sample Problem 2 Output

```
LEG  8              LENGTH =  1.00E+05 FT
********              AREA =  1.80E+06 FT**2
              CONDUCTIVITY =  1.46E+04 FT/YR
                  POROSITY =   .3000
              ROCK DENSITY =  1.19E+02 LB/FT**3
             FLUID DENSITY =  6.23E+01 LB/FT**3
           FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  9              LENGTH =  6.00E+02 FT
********              AREA =  7.07E+02 FT**2
              CONDUCTIVITY =  3.65E+01 FT/YR
                  POROSITY =   .1500
              ROCK DENSITY =  1.45E+02 LB/FT**3
             FLUID DENSITY =  7.02E+01 LB/FT**3
           FLUID VISCOSITY =  1.27E+00 CP

                LEG PROPERTIES

LEG 10              LENGTH =  4.97E+02 FT
********              AREA =  1.00E+00 FT**2
              CONDUCTIVITY =  3.65E+03 FT/YR
                  POROSITY =   .1500
              ROCK DENSITY =  1.45E+02 LB/FT**3
             FLUID DENSITY =  7.40E+01 LB/FT**3
           FLUID VISCOSITY =  1.43E+00 CP

                LEG PROPERTIES

LEG 11              LENGTH =  5.00E+02 FT
********              AREA =  1.00E+00 FT**2
              CONDUCTIVITY =  6.10E-04 FT/YR
                  POROSITY =   .0300
              ROCK DENSITY =  1.65E+02 LB/FT**3
             FLUID DENSITY =  7.40E+01 LB/FT**3
           FLUID VISCOSITY =  1.43E+00 CP

                LEG PROPERTIES

LEG 12              LENGTH =  6.04E+02 FT
********              AREA =  1.00E+00 FT**2
              CONDUCTIVITY =  5.48E-04 FT/YR
                  POROSITY =   .0300
              ROCK DENSITY =  1.65E+02 LB/FT**3
             FLUID DENSITY =  7.40E+01 LB/FT**3
           FLUID VISCOSITY =  1.43E+00 CP

                LEG PROPERTIES

LEG 13              LENGTH =  8.00E+03 FT
********              AREA =  5.40E+02 FT**2
              CONDUCTIVITY =  3.65E+03 FT/YR
                  POROSITY =   .3000
              ROCK DENSITY =  1.19E+02 LB/FT**3
             FLUID DENSITY =  7.40E+01 LB/FT**3
           FLUID VISCOSITY =  1.43E+00 CP

                LEG PROPERTIES

LEG 14              LENGTH =  1.10E+03 FT
********              AREA =  1.00E+00 FT**2
              CONDUCTIVITY =  5.73E-04 FT/YR
                  POROSITY =   .0300
```

Table 6-SP. (cont'd) Sample Problem 2 Output

FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 15
****

LENGTH = 1.16E+03 FT
AREA = 1.20E+08 FT**2
CONDUCTIVITY = 9.13E+02 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

DISTRIBUTION COEFFICIENTS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	0.	0.	0.
LEG10	0.	0.	0.
LEG 3	.16000E+01	.16000E+01	.16000E+01
LEG 4	.16000E+01	.16000E+01	.16000E+01

RETARDATION FACTORS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	.10000E+01	.10000E+01	.10000E+01
LEG10	.10000E+01	.10000E+01	.10000E+01
LEG 3	.63567E+03	.63567E+03	.63567E+03
LEG 4	.63567E+03	.63567E+03	.63567E+03

LEG NO.	FLOW VOL. (CU FT)/DAY	DARCY VEL. FT/DAY	PORE VEL. FT/DAY
1	3.88E+06	6.47E-01	2.16E+00
2	3.88E+06	6.47E-01	2.16E+00
3	3.88E+06	6.47E-01	2.16E+00
4	3.88E+06	6.47E-01	2.16E+00
5	6.58E+05	3.66E-01	1.22E+00
6	6.58E+05	3.66E-01	1.22E+00
7	6.58E+05	3.66E-01	1.22E+00
8	6.58E+05	3.66E-01	1.22E+00
9	-1.02E+00	-1.45E-03	-9.65E-03
10	1.02E+00	1.02E+00	6.82E+00
11	-1.66E-06	-1.66E-06	-5.54E-05
12	-1.39E-06	-1.39E-06	-4.64E-05
13	1.02E+00	1.89E-03	6.32E-03
14	-5.83E-07	-5.83E-07	-1.94E-05
15	6.58E+05	5.48E-03	1.83E-02

TOTAL PATH LENGTH (FT) = 1.4250E+05
FROM DEPOSITORY MIDPT (FT) = 1.4250E+05
AVERAGE FLUID VELOCITY (FT/Y) = 7.4586E+01

Table 6-SP. (cont'd) Sample Problem 2 Output

YEAR	NP237	U233	TH229
75263.	.15352E-10	.15675E-10	.15688E-10
76142.	.31096E-10	.31758E-10	.31784E-10
77021.	.61256E-10	.62573E-10	.62625E-10
77901.	.11747E-09	.12002E-09	.12012E-09
78780.	.21949E-09	.22430E-09	.22450E-09
79659.	.39998E-09	.40883E-09	.40919E-09
80538.	.71145E-09	.72734E-09	.72798E-09
81418.	.12362E-08	.12641E-08	.12652E-08
82297.	.21000E-08	.21478E-08	.21497E-08
83176.	.34904E-08	.35705E-08	.35738E-08
84056.	.56800E-08	.58116E-08	.58169E-08
84935.	.90563E-08	.92679E-08	.92764E-08
85814.	.14157E-07	.14491E-07	.14504E-07
86693.	.21712E-07	.22228E-07	.22249E-07
87573.	.32688E-07	.33472E-07	.33504E-07
88452.	.48341E-07	.49510E-07	.49557E-07
89331.	.70262E-07	.71975E-07	.72044E-07
90211.	.10043E-06	.10290E-06	.10300E-06
91090.	.14124E-06	.14474E-06	.14488E-06
91969.	.19553E-06	.20042E-06	.20062E-06
92848.	.26663E-06	.27334E-06	.27362E-06
93728.	.35827E-06	.36736E-06	.36773E-06
94607.	.47462E-06	.48675E-06	.48725E-06
95486.	.62016E-06	.63614E-06	.63679E-06
96366.	.79963E-06	.82039E-06	.82124E-06
97245.	.10179E-05	.10445E-05	.10456E-05
98124.	.12796E-05	.13133E-05	.13147E-05
99004.	.15895E-05	.16317E-05	.16334E-05
99883.	.19516E-05	.20038E-05	.20059E-05
100762.	.23695E-05	.24332E-05	.24359E-05
101641.	.28458E-05	.29230E-05	.29262E-05
102521.	.33824E-05	.34748E-05	.34786E-05
103400.	.39799E-05	.40893E-05	.40939E-05
104279.	.46378E-05	.47661E-05	.47714E-05
105159.	.53541E-05	.55032E-05	.55094E-05
106038.	.61257E-05	.62975E-05	.63046E-05
106917.	.69482E-05	.71444E-05	.71526E-05
107796.	.78161E-05	.80383E-05	.80475E-05
108676.	.87227E-05	.89723E-05	.89827E-05
109555.	.96607E-05	.99389E-05	.99504E-05
110434.	.10622E-04	.10930E-04	.10942E-04
111314.	.11598E-04	.11936E-04	.11950E-04
112193.	.12579E-04	.12948E-04	.12964E-04
113072.	.13558E-04	.13959E-04	.13975E-04
113951.	.14526E-04	.14958E-04	.14976E-04
114831.	.15475E-04	.15937E-04	.15957E-04
115710.	.16397E-04	.16890E-04	.16911E-04
116589.	.17286E-04	.17809E-04	.17831E-04
117469.	.18137E-04	.18689E-04	.18712E-04
118348.	.18945E-04	.19525E-04	.19549E-04
119227.	.19706E-04	.20313E-04	.20338E-04
120107.	.20417E-04	.21050E-04	.21076E-04
120986.	.21078E-04	.21734E-04	.21762E-04
121865.	.21687E-04	.22366E-04	.22395E-04
122744.	.22244E-04	.22945E-04	.22974E-04
123624.	.22750E-04	.23471E-04	.23501E-04
124503.	.23207E-04	.23946E-04	.23978E-04
125382.	.23617E-04	.24373E-04	.24405E-04
126262.	.23982E-04	.24754E-04	.24787E-04
127141.	.24305E-04	.25092E-04	.25125E-04

Table 6-SP (cont'd) Sample Problem 2 Output

YEAR	NP237	U233	TH229
128020.	.24589E-04	.25389E-04	.25423E-04
128895.	.24837E-04	.25649E-04	.25684E-04
129779.	.25052E-04	.25876E-04	.25911E-04
130658.	.25238E-04	.26072E-04	.26107E-04
131537.	.25396E-04	.26240E-04	.26276E-04
132417.	.25531E-04	.26384E-04	.26420E-04
133296.	.25645E-04	.26506E-04	.26542E-04
134175.	.25741E-04	.26609E-04	.26646E-04
135054.	.25820E-04	.26695E-04	.26732E-04
135934.	.25886E-04	.26767E-04	.26805E-04
136813.	.25939E-04	.26827E-04	.26865E-04
137692.	.25982E-04	.26876E-04	.26914E-04
138572.	.26017E-04	.26916E-04	.26954E-04
139451.	.26044E-04	.26948E-04	.26986E-04
140330.	.26064E-04	.26974E-04	.27012E-04
141209.	.26080E-04	.26994E-04	.27033E-04
142089.	.26091E-04	.27010E-04	.27049E-04
142968.	.26099E-04	.27022E-04	.27062E-04
143947.	.26104E-04	.27031E-04	.27071E-04
144727.	.26106E-04	.27038E-04	.27078E-04
145606.	.26107E-04	.27043E-04	.27082E-04
146485.	.26105E-04	.27045E-04	.27086E-04
147365.	.26103E-04	.27047E-04	.27087E-04
148244.	.26099E-04	.27047E-04	.27088E-04
149123.	.26095E-04	.27047E-04	.27088E-04
150002.	.26090E-04	.27046E-04	.27087E-04
150882.	.26084E-04	.27044E-04	.27085E-04
151761.	.26078E-04	.27042E-04	.27083E-04
152640.	.26072E-04	.27040E-04	.27081E-04
153520.	.26065E-04	.27037E-04	.27079E-04
154399.	.26059E-04	.27034E-04	.27076E-04
155278.	.26052E-04	.27031E-04	.27073E-04
156157.	.26045E-04	.27028E-04	.27070E-04
157037.	.26038E-04	.27024E-04	.27067E-04
157916.	.26030E-04	.27021E-04	.27063E-04
158795.	.26023E-04	.27017E-04	.27060E-04
159675.	.26016E-04	.27014E-04	.27056E-04
160554.	.26009E-04	.27010E-04	.27053E-04
161433.	.26001E-04	.27006E-04	.27049E-04
162312.	.25994E-04	.27002E-04	.27046E-04
163192.	.25987E-04	.26999E-04	.27042E-04
164071.	.25979E-04	.26995E-04	.27039E-04
164950.	.25972E-04	.26991E-04	.27035E-04
165830.	.25964E-04	.26987E-04	.27031E-04
166709.	.25957E-04	.26983E-04	.27028E-04
167588.	.25950E-04	.26980E-04	.27024E-04
168468.	.25942E-04	.26976E-04	.27020E-04
169347.	.25935E-04	.26972E-04	.27017E-04
170226.	.25928E-04	.26968E-04	.27013E-04
171105.	.25920E-04	.26964E-04	.27009E-04
171985.	.25913E-04	.26960E-04	.27005E-04
172864.	.25905E-04	.26956E-04	.27002E-04
173743.	.25898E-04	.26952E-04	.26998E-04
174523.	.25891E-04	.26948E-04	.26994E-04
175502.	.25883E-04	.26944E-04	.26990E-04
176381.	.25876E-04	.26940E-04	.26986E-04
177260.	.25868E-04	.26936E-04	.26982E-04
178140.	.25861E-04	.26932E-04	.26978E-04
179019.	.25854E-04	.26928E-04	.26974E-04
179898.	.25846E-04	.26924E-04	.26970E-04

Table 6-SP. (cont'd) Sample Problem 2 Output

YEAR	NP237	U233	TH229
180778.	.25838E-04	.26919E-04	.26966E-04
181657.	.25830E-04	.26915E-04	.26962E-04
182536.	.25822E-04	.26909E-04	.26957E-04
183415.	.25813E-04	.26904E-04	.26951E-04
184295.	.25803E-04	.26897E-04	.26945E-04
185174.	.25792E-04	.26889E-04	.26937E-04
186053.	.25780E-04	.26879E-04	.26927E-04
186933.	.25764E-04	.26867E-04	.26915E-04
187912.	.25745E-04	.26850E-04	.26898E-04
188691.	.25721E-04	.26829E-04	.26877E-04
189571.	.25691E-04	.26800E-04	.26849E-04
190450.	.25651E-04	.26763E-04	.26811E-04
191329.	.25601E-04	.26714E-04	.26763E-04
192208.	.25537E-04	.26651E-04	.26699E-04
193088.	.25456E-04	.26570E-04	.26618E-04
193967.	.25354E-04	.26466E-04	.26515E-04
194846.	.25227E-04	.26337E-04	.26385E-04
195726.	.25070E-04	.26177E-04	.26225E-04
196605.	.24879E-04	.25981E-04	.26028E-04
197484.	.24650E-04	.25744E-04	.25792E-04
198363.	.24377E-04	.25462E-04	.25509E-04
199243.	.24056E-04	.25130E-04	.25177E-04
200122.	.23684E-04	.24744E-04	.24791E-04
201001.	.23257E-04	.24301E-04	.24347E-04
201881.	.22772E-04	.23798E-04	.23843E-04
202760.	.22230E-04	.23234E-04	.23278E-04
203639.	.21628E-04	.22608E-04	.22650E-04
204518.	.20968E-04	.21921E-04	.21962E-04
205398.	.20252E-04	.21175E-04	.21215E-04
206277.	.19484E-04	.20374E-04	.20413E-04
207156.	.18668E-04	.19523E-04	.19560E-04
208036.	.17810E-04	.18628E-04	.18663E-04
208915.	.16916E-04	.17695E-04	.17729E-04
209794.	.15993E-04	.16732E-04	.16764E-04
210674.	.15051E-04	.15748E-04	.15778E-04
211553.	.14097E-04	.14751E-04	.14780E-04
212432.	.13139E-04	.13750E-04	.13777E-04
213311.	.12186E-04	.12755E-04	.12779E-04
214191.	.11246E-04	.11772E-04	.11795E-04
215070.	.10326E-04	.10811E-04	.10832E-04
215949.	.94344E-05	.98781E-05	.98975E-05
216829.	.85757E-05	.89801E-05	.89978E-05
217708.	.77557E-05	.81224E-05	.81384E-05
218587.	.69785E-05	.73092E-05	.73237E-05
219466.	.62473E-05	.65442E-05	.65572E-05
220346.	.55645E-05	.58295E-05	.58411E-05
221225.	.49313E-05	.51668E-05	.51771E-05
222104.	.43483E-05	.45565E-05	.45656E-05
222984.	.38151E-05	.39982E-05	.40063E-05
223863.	.33308E-05	.34910E-05	.34981E-05
224742.	.28937E-05	.30332E-05	.30393E-05
225621.	.25017E-05	.26226E-05	.26279E-05
226501.	.21524E-05	.22567E-05	.22613E-05
227380.	.18430E-05	.19326E-05	.19365E-05
228259.	.15707E-05	.16472E-05	.16505E-05
229139.	.13323E-05	.13974E-05	.14002E-05
230018.	.11250E-05	.11800E-05	.11824E-05
230897.	.94553E-06	.99189E-06	.99393E-06
231776.	.79114E-06	.83002E-06	.83173E-06
232656.	.65902E-06	.69148E-06	.69291E-06

Table 6-SP (cont'd) Sample Problem 2 Output

YEAR	NP237	U233	TH229
233535.	.54655E-06	.57354E-06	.57472E-06
234414.	.45132E-06	.47365E-06	.47464E-06
235294.	.37109E-06	.38950E-06	.39030E-06
236173.	.30384E-06	.31894E-06	.31961E-06
237052.	.24774E-06	.26008E-06	.26063E-06
237932.	.20117E-06	.21122E-06	.21166E-06
238811.	.16270E-06	.17084E-06	.17120E-06
239690.	.13106E-06	.13764E-06	.13793E-06
240569.	.10516E-06	.11045E-06	.11068E-06
241449.	.84056E-07	.88290E-07	.88477E-07
242328.	.66929E-07	.70309E-07	.70457E-07
243207.	.53093E-07	.55779E-07	.55897E-07
244087.	.41961E-07	.44089E-07	.44183E-07
244966.	.33043E-07	.34722E-07	.34796E-07
245845.	.25927E-07	.27247E-07	.27305E-07
246724.	.20272E-07	.21306E-07	.21352E-07
247604.	.15795E-07	.16602E-07	.16638E-07
248483.	.12264E-07	.12893E-07	.12921E-07
249362.	.94911E-08	.99785E-08	.10000E-07
250242.	.73206E-08	.76973E-08	.77139E-08
251121.	.56279E-08	.59181E-08	.59309E-08
252000.	.43127E-08	.45356E-08	.45454E-08

```
OPTIONS 1,0  2,0  3,0  4,0  5,0  6,1  7,1  8,0  9,0 10,0 11,0 12,0 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0
 NO OF VECTORS =    0 TIME UPPER BOUND =          1.00E+06

                 THE SPACE STEP................  DX  = 8.00000E+03 FT
                 THE TIME STEP.................  DT  = 1.89646E+04 Y
                 NO OF SOURCE BLKS.............  NSB =     1
```

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER
NP237	(DECAY)	.12589E+01	.99388E+00	.30964E+01
U233	(DECAY)	.12589E+01	.92206E+00	.30964E+01
U233	NP237	.12589E+01	.58817E-02	.30964E+01
TH229	(DECAY)	.12589E+01	.16518E+00	.30964E+01
TH229	U233	.12589E+01	.35716E-01	.30964E+01
TH229	U233 NP237	.12589E+01	.14370E-03	.30964E+01

Table 6-SP. (cont'd) Sample Problem 2 Output

YEAR	NP237	U233	TH229
37929.	0.	0.	0.
56894.	0.	0.	0.
75858.	.14113E-11	.13623E-11	.54360E-12
94823.	.60138E-06	.61782E-06	.61553E-06
113787.	.13729E-04	.14172E-04	.14443E-04
132752.	.25150E-04	.26030E-04	.26405E-04
151716.	.26070E-04	.27072E-04	.27453E-04
170681.	.25924E-04	.27004E-04	.27388E-04
189646.	.25341E-04	.26473E-04	.26861E-04
208610.	.15770E-04	.16509E-04	.16697E-04
227575.	.41069E-05	.43077E-05	.43416E-05
246539.	.29709E-06	.31213E-06	.31332E-06
265504.	.34179E-08	.35977E-08	.36063E-08
284469.	.29321E-11	.30923E-11	.30994E-11
303433.	0.	0.	0.
322398.	0.	0.	0.
341362.	0.	0.	0.
360327.	0.	0.	0.
379291.	0.	0.	0.
398256.	0.	0.	0.
417220.	0.	0.	0.
436185.	0.	0.	0.
455149.	0.	0.	0.
474114.	0.	0.	0.
493079.	0.	0.	0.
512043.	0.	0.	0.
531008.	0.	0.	0.
549972.	0.	0.	0.
568937.	0.	0.	0.
587901.	0.	0.	0.
606865.	0.	0.	0.
625831.	0.	0.	0.
644795.	0.	0.	0.
663760.	0.	0.	0.
682724.	0.	0.	0.
701689.	0.	0.	0.
720653.	0.	0.	0.
739618.	0.	0.	0.
758582.	0.	0.	0.
777547.	0.	0.	0.
796512.	0.	0.	0.
815476.	0.	0.	0.
834441.	0.	0.	0.
853405.	0.	0.	0.
872370.	0.	0.	0.
891334.	0.	0.	0.
910299.	0.	0.	0.
929263.	0.	0.	0.
948228.	0.	0.	0.
967193.	0.	0.	0.
986157.	0.	0.	0.
1005122.	0.	0.	0.

Table 6-SP. (cont'd) Sample Problem 2 Output

DVM / STC

New Right Hand Page

Notebook Divider Should Read: S.P. 3 – Effect of Source Length on Output Pulse

(Abbreviate as necessary)

Sample Problems 3A and 3B: Effect of Source Length on Output Pulse

Problem 3 has two parts which demonstrate the effect of source length on the output pulse. The U-Tube breachment and the decay chain are those of problem 2. However, different distribution coefficients are assigned to each isotope in the upper aquifer. Also a family of withdrawal wells is assumed to exist 20000 ft down-dip from the depository. They are assumed to withdraw 20% of the aquifer flow. Input is described in terms of changes to problem 2.

The first data set is used for problem 3A (Table 7-SP).

BC(1) A different title.

SAMPLE PROBLEM NO. 3

BC(2) All options are set to zero except option 12 which indicates that the well card is to be read.

BC(11) Enter 3, 20000., and .2 indicating that the wells are on leg 3, 20000 ft down-dip, and are withdrawing .2 of the aquifer flow.

BC(13) The KD's in legs 3 and 4 are defined by

NP237	KD = 10. ft^3/lb
U233	KD = 1.6 ft^3/lb
TH229	KD = 1.0 ft^3/lb

BC(15) The extent over which source is spread has a default value of 8000 ft (the length of leg 13). Thus, a blank card here suffices for 3A.

BC(18) Set TUB = 3.5×10^5y.

The second data set is problem 3B (Table 7-SP). The INP card has ones in columns 1 and 15 so that the options card and the DVM control card are reread.

BC(2) Set options 6 and 7 to 1 to suppress some duplicated output.

BC(15) Set the source length, DEPLEN, equal to 2000 ft.

BC(18) Set TUB = 3.5×10^5y.

Figures 6-SP and 7-SP display discharge rates versus time for problems 3A and 3B. Also included are results obtained by using the computer code GETOUT. GETOUT was executed in its step-with-dispersion mode. The decaying step boundary condition is used to simulate a leach limited source with constant leach rate. Note the comparison between NWFT/DVM and GETOUT in Figure 6-SP. For NP237, GETOUT predicts a higher peak discharge rate than NWFT/DVM. Note also that the NP237 discharge pulse predicted by NWFT/DVM seems shifted to later times. These differences in NWFT/DVM and GETOUT predictions can be attributed to the different source treatments used in the two models. GETOUT uses a concentration boundary condition whereas NWFT/DVM injects source material into grid blocks. In this example, the distance from the center of the 8000 ft distributed source to the discharge point in NWFT/DVM is the same as the distance from the source boundary to the discharge point in GETOUT. Intuitively, one might expect that a distributed source would produce a lower peak discharge rate than a boundary condition source. Furthermore, when the source input terminates, as determined by the leach time, the distributed source in NWFT/DVM gives an additional 4000 ft of source pulse. This latter effect explains the reason why the discharge pulse tail arrives later in the NWFT/DVM results than in the GETOUT results. Without arguing the relative merits of the different source treatments, we simply note that one could expect better agreement between NWFT/DVM and GETOUT if the distributed source in NWFT/DVM were smaller. This effect is shown in Figure 7-SP in which the source length was reduced from 8000 ft to 2000 ft. Code output is given in TAble 8-SP.

Table 7-SP. Sample Problem 3 Input Data

```
               SAMPLE PROBLEM NO. 3
            1                                                                                      BC   1
 432.70    646.10    432.70                                                                        BC   2
   50.0      50.0      50.0      50.0      40.0      40.0      40.0      40.0                      BC   3
     .1       10.  1.67E-6    1.5E-6       10.  1.57E-6       2.5                                  BC   4
   6.E6      6.E6      6.E6      6.E6     1.8E6     1.8E6     1.8E6     1.8E6                      BC   4
   707.       1.0        1.       1.0      540.        1.     1.2E8                                BC   5
 14500.     8000.    38000.   100000.    14500.     8000.    38000.   100000.                      BC   5
   600.     496.5      500.     603.5     8000.     1100.     1100.                                BC   6
3602.41   2502.41   1525.89   3414.81   3311.31   2814.81   2814.81   2314.81                      BC   6
2211.31   2819.67   1719.67    425.89                                                              BC   7
     .3        .3        .3        .3        .3        .3        .3        .3                      BC   7
    .15       .15       .03       .03        .3       .03        .3                                BC   8
     0.        0.        0.        0.        0.        0.        0.        0.                      BC   8
   -.67        1.        1.        1.        1.        1.        0.                                BC   9
4    13    10     3    4                                                                           BC   9
3        2.E4          .2                                                                          BC  10
3                                                                                                  BC  11
   237.     NP237         1         0    2.14E6      1.E3                                          BC  12
   233.      U233         2         1    1.62E5      1.E3                                          BC  12
      1        1.                                                                                  BC  12
   229.     TH229         3         1     7.3E3      1.E3                                          BC  12
      2        1.                                                                                  BC  12
                        10.       10.                                                              BC  12
                        1.6       1.6                                                              BC  13
                        1.0       1.0                                                              BC  13
   1.E5      500.                                                                                  BC  13
                                                                                                   BC  14
              3.5E5                                                                                BC  15
1             1                                                                                    BC  18
  11    1                                                                                          BC   0
       2000.                                                                                       BC   2
              3.5E5                                                                                BC  15
                                                                                                   BC  18
```

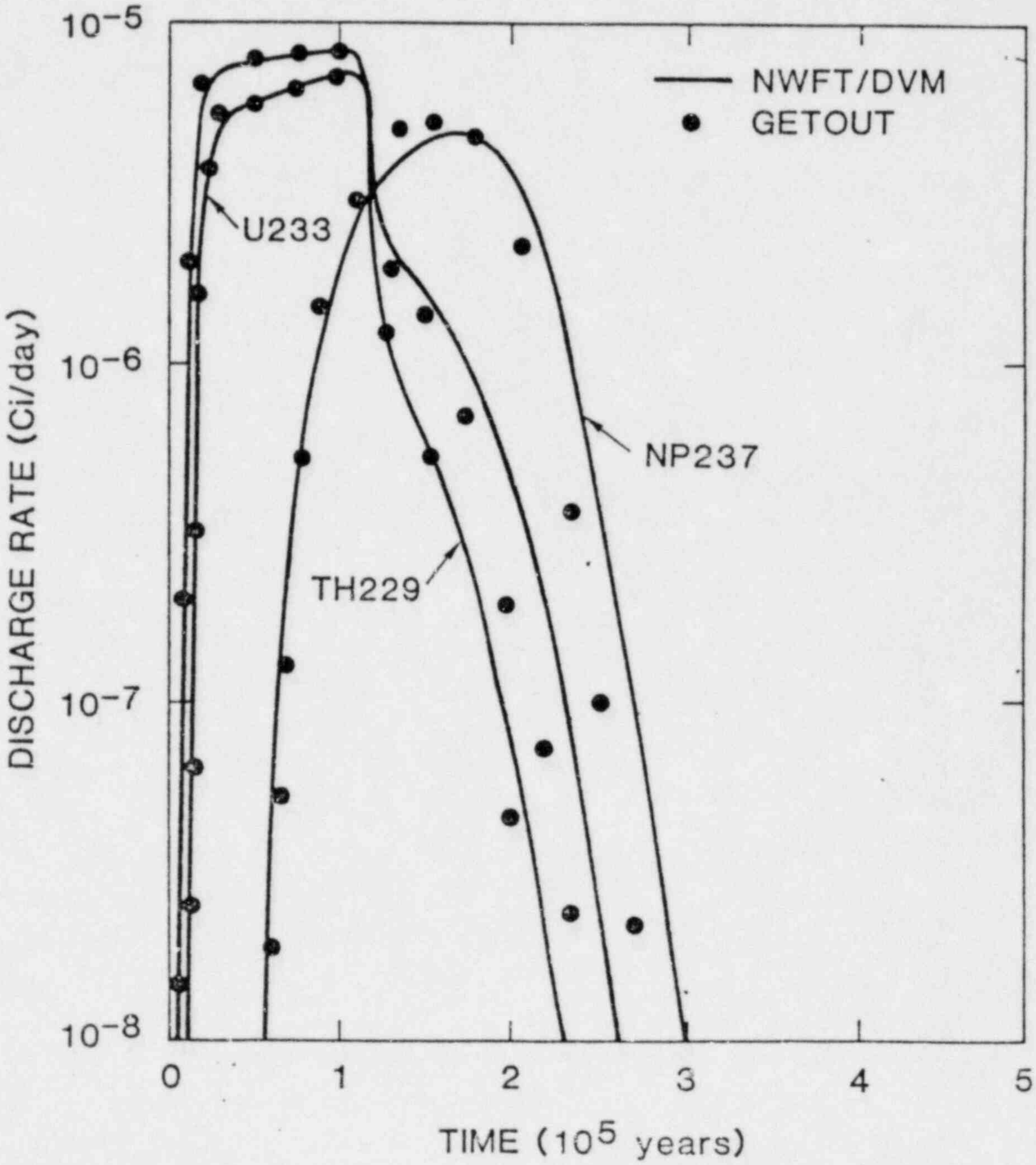


Figure 6-SP. Discharge Rates for Problem 3A

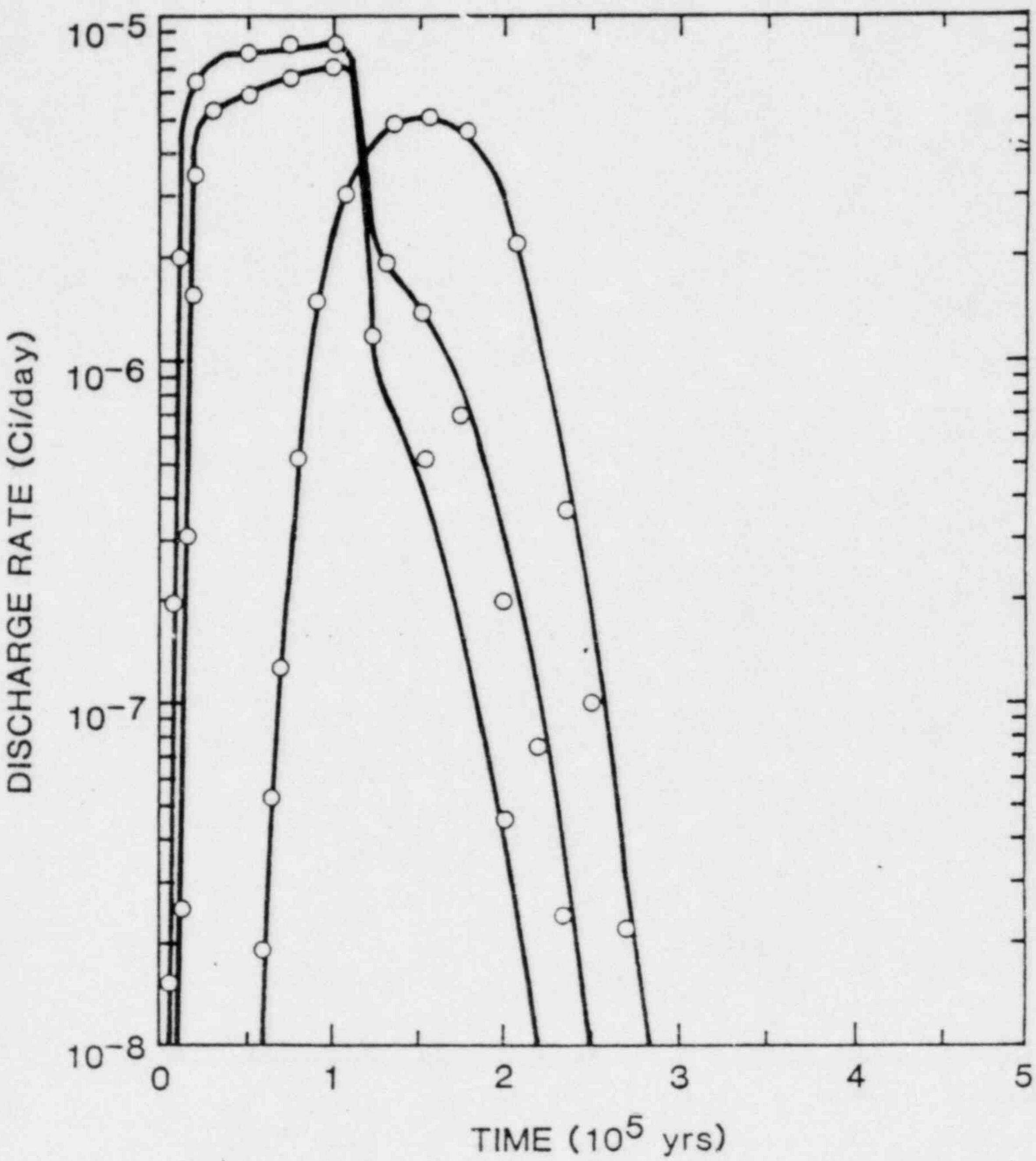
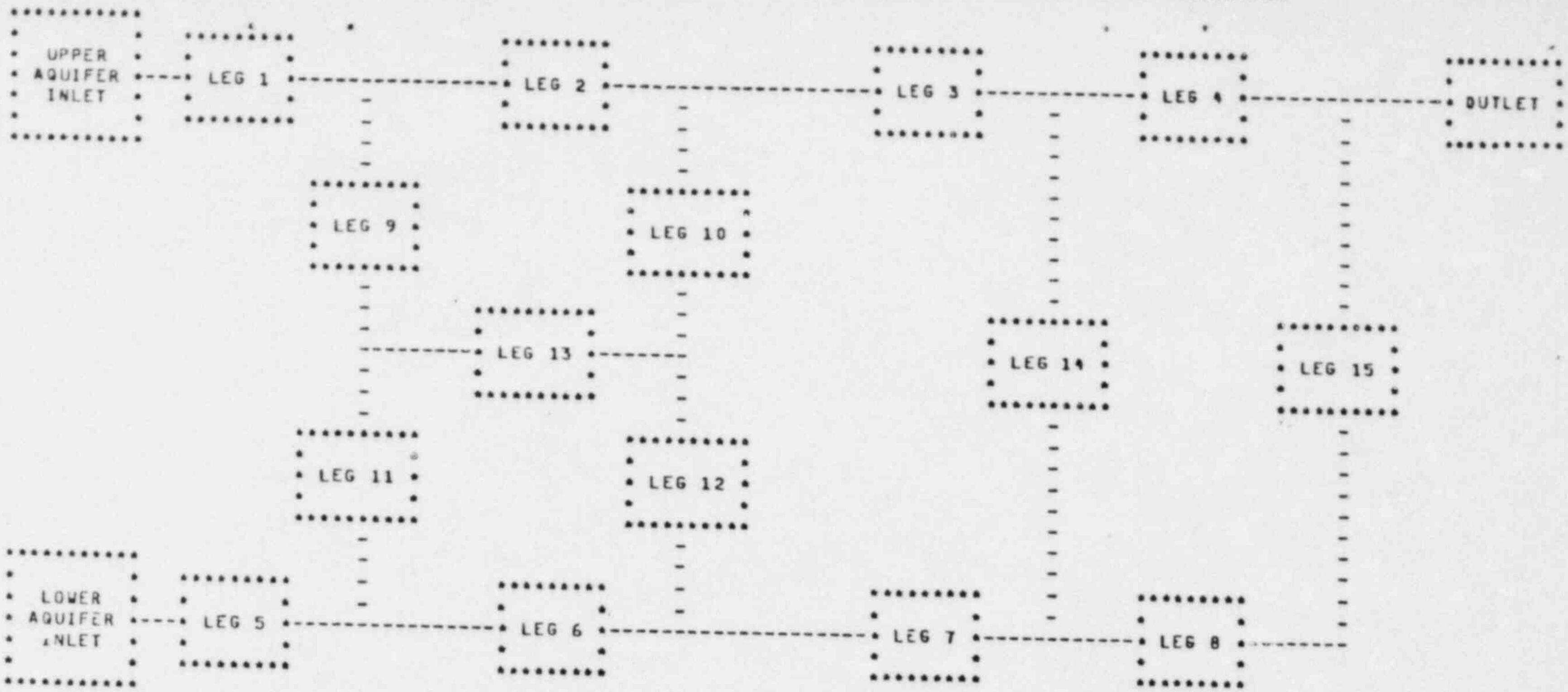


Figure 7-SP. Discharge Rates vs. Time
for Problem 3B

```
OPTIONS 1,0  2,0  3,0  4,0  5,0  6,0  7,0  8,0  9,0 10,0 11,0 12,1 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0
 NUMBER OF ISOTOPES     3

        ISOTOPE NAME             HALF LIFE (YEARS)     INITIAL AMOUNT (CI)

           NP237                    2.140E+06              1.000E+03
            U233                    1.620E+05              1.000E+03
           TH229                    7.300E+03              1.000E+03

        LEACH TIME =     1.000E+05 YEARS      DISPERSIVITY =    5.000E+02 FEET

NO OF VECTORS =    0 TIME UPPER BOUND =         3.50E+05
```

Table 8-SP. Sample Problem 3 Output

NETWORK FLOW MODEL




```
------RADIONUCLIDE MIGRATION PATH------LEGS    13   10    3

          UPPER AQUIFER INLET
      INLET PRESSURE = 62308.80 LB/FT**2
           ELEVATION =  3602.41 FT

          LOWER AQUIFER INLET
      INLET PRESSURE = 93038.40 LB/FT**2
           ELEVATION =  2502.41 FT

              OUTLET
     OUTLET PRESSURE = 62308.80 LB/FT**2
           ELEVATION =  1525.89 FT

            ELEVATIONS OF OTHER POINTS
     JUNCTION 4 (LEGS 1-2-9) =     3414.81 FT
    JUNCTION 5 (LEGS 2-3-10) =     3311.31 FT
    JUNCTION 6 (LEGS 9-11-13) =    2814.81 FT
   JUNCTION 7 (LEGS 10-12-13) =    2814.81 FT
     JUNCTION 8 (LEGS 5-6-11) =    2314.81 FT
     JUNCTION 9 (LEGS 6-7-12) =    2211.31 FT
    JUNCTION10 (LEGS 3-4-14) =     2819.67 FT
    JUNCTION11 (LEGS 7-8-14) =     1719.67 FT
      JUNCTION12 (LEGS 8-15) =      425.89 FT

                LEG PROPERTIES

LEG  1            LENGTH =  1.45E+04 FT
********            AREA =  6.00E+06 FT**2
```

Table 8-SP. (cont'd) Sample Problem 3 Output

```
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP

                     LEG PROPERTIES

 LEG  2               LENGTH =  8.00E+03 FT
 ********               AREA =  6.00E+06 FT**2
                CONDUCTIVITY =  1.83E+04 FT/YR
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP

                     LEG PROPERTIES

 LEG  3               LENGTH =  3.80E+04 FT
 ********               AREA =  6.00E+06 FT**2
                CONDUCTIVITY =  1.83E+04 FT/YR
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP

                     LEG PROPERTIES

 LEG  4               LENGTH =  1.00E+05 FT
 ********               AREA =  6.00E+06 FT**2
                CONDUCTIVITY =  1.83E+04 FT/YR
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP

                     LEG PROPERTIES

 LEG  5               LENGTH =  1.45E+04 FT
 ********               AREA =  1.80E+06 FT**2
                CONDUCTIVITY =  1.46E+04 FT/YR
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP

                     LEG PROPERTIES

 LEG  6               LENGTH =  8.00E+03 FT
 ********               AREA =  1.80E+06 FT**2
                CONDUCTIVITY =  1.46E+04 FT/YR
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP

                     LEG PROPERTIES

 LEG  7               LENGTH =  3.80E+04 FT
 ********               AREA =  1.80E+06 FT**2
                CONDUCTIVITY =  1.46E+04 FT/YR
                    POROSITY =    .3000
                ROCK DENSITY =  1.19E+02 LB/FT**3
               FLUID DENSITY =  6.23E+01 LB/FT**3
             FLUID VISCOSITY =  1.00E+00 CP
```

Table 8-SP. (cont'd) Sample Problem 3 Output

LEG 8
****
LENGTH = 1.00E+05 FT
AREA = 1.80E+06 FT**2
CONDUCTIVITY = 1.46E+04 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

LEG PROPERTIES

LEG 9
****
LENGTH = 6.00E+02 FT
AREA = 7.07E+02 FT**2
CONDUCTIVITY = 3.65E+01 FT/YR
POROSITY = .1500
ROCK DENSITY = 1.45E+02 LB/FT**3
FLUID DENSITY = 7.02E+01 LB/FT**3
FLUID VISCOSITY = 1.27E+00 CP

LEG PROPERTIES

LEG 10
****
LENGTH = 4.97E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 3.65E+03 FT/YR
POROSITY = .1500
ROCK DENSITY = 1.45E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 11
****
LENGTH = 5.00E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 6.10E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 12
****
LENGTH = 6.04E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.48E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 13
****
LENGTH = 8.00E+03 FT
AREA = 5.40E+02 FT**2
CONDUCTIVITY = 3.65E+03 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 14
****
LENGTH = 1.10E+03 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.73E-04 FT/YR
POROSITY = .0300

Table 8-SP. (cont'd) Sample Problem 3 Output

FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 15	LENGTH =	1.10E+03 FT
********	AREA =	1.20E+08 FT**2
	CONDUCTIVITY =	9.13E+02 FT/YR
	POROSITY =	.3000
	ROCK DENSITY =	1.19E+02 LB/FT**3
	FLUID DENSITY =	6.23E+01 LB/FT**3
	FLUID VISCOSITY =	1.00E+00 CP

DISTRIBUTION COEFFICIENTS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	0.	0.	0.
LEG10	0.	0.	0.
LEG 3	.10000E+02	.16000E+01	.10000E+01

RETARDATION FACTORS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	.10000E+01	.10000E+01	.10000E+01
LEG10	.10000E+01	.10000E+01	.10000E+01
LEG 3	.39677E+04	.63567E+03	.39767E+03

LEG NO.	FLOW VOL. (CU FT)/DAY	DARCY VEL. FT/DAY	PORE VEL. FT/DAY
1	3.88E+06	6.47E-01	2.16E+00
2	3.88E+06	6.47E-01	2.16E+00
3	3.88E+06	6.47E-01	2.16E+00
4	3.88E+06	6.47E-01	2.16E+00
5	6.58E+05	3.66E-01	1.22E+00
6	6.58E+05	3.66E-01	1.22E+00
7	6.58E+05	3.66E-01	1.22E+00
8	6.58E+05	3.66E-01	1.22E+00
9	-1.02E+00	-1.45E-03	-9.65E-03
10	1.02E+00	1.02E+00	6.82E+00
11	-1.66E-06	-1.66E-06	-5.54E-05
12	-1.39E-06	-1.39E-06	-4.64E-05
13	1.02E+00	1.89E-03	6.32E-03
14	-5.83E-07	-5.83E-07	-1.94E-05
15	6.58E+05	5.48E-03	1.83E-02

TOTAL PATH LENGTH (FT) = 2.8497E+04
FROM DEPOSITORY MIDPT (FT) = 2.4497E+04
AVERAGE FLUID VELOCITY (FT/Y) = 1.3914E+01

THE SPACE STEP................ DX = 1.14281E+03 FT
THE TIME STEP................. DT = 4.78459E+03 Y
NO OF SOURCE BLKS............ NSB = 7

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER
NP237	(DECAY)	.23885E+00	.99845E+00	.10026E+01
U233	(DECAY)	.13694E+01	.97974E+00	.57481E+01

Table 8-SP. (cont'd) Sample Problem 3 Output

		[illegible]	[illegible]	.33734E+01
TH229	(DECAY)	.20689E+01	.63489E+00	.86842E+01
TH229	* U233 *	.17192E+01	.16273E-01	.72162E+01

Table 8-SP. (cont'd) Sample Problem 3 Output

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	NP237	U233	TH229
9569.	0.	.12016E-08	.52592E-06
14354.	0.	.81100E-06	.34753E-05
19138.	0.	.31070E-05	.59207E-05
23923.	0.	.46151E-05	.69627E-05
28708.	0.	.51724E-05	.73191E-05
33492.	.56405E-12	.53991E-05	.74786E-05
38277.	.27903E-10	.55447E-05	.75886E-05
43061.	.37649E-09	.56722E-05	.76836E-05
47846.	.25102E-08	.57961E-05	.77710E-05
52630.	.10652E-07	.59194E-05	.78522E-05
57415.	.32995E-07	.60426E-05	.79271E-05
62200.	.81165E-07	.61653E-05	.79957E-05
66984.	.16766E-06	.62866E-05	.80578E-05
71769.	.30239E-06	.64052E-05	.81135E-05
76553.	.48997E-06	.65198E-05	.81629E-05
81338.	.72859E-06	.66290E-05	.82062E-05
86123.	.10108E-05	.67315E-05	.82439E-05
90907.	.13250E-05	.68264E-05	.82764E-05
95692.	.16583E-05	.69130E-05	.83040E-05
100476.	.19977E-05	.69911E-05	.83273E-05
105261.	.23320E-05	.70605E-05	.82951E-05
110046.	.26522E-05	.70411E-05	.76301E-05
114830.	.29521E-05	.63470E-05	.49051E-05
119615.	.32278E-05	.41571E-05	.23772E-05
124399.	.34772E-05	.25578E-05	.13285E-05
129184.	.37001E-05	.20934E-05	.10581E-05
133968.	.38972E-05	.19611E-05	.94282E-06
138753.	.40700E-05	.18642E-05	.84482E-06
143538.	.42203E-05	.17654E-05	.75141E-06
148322.	.43498E-05	.16630E-05	.66241E-06
153107.	.44599E-05	.15572E-05	.57830E-06
157891.	.45517E-05	.14485E-05	.49953E-06
162676.	.46246E-05	.13373E-05	.42656E-06
167461.	.46755E-05	.12239E-05	.35980E-06
172245.	.46974E-05	.11091E-05	.29956E-06
177030.	.46790E-05	.99368E-06	.24603E-06
181814.	.46067E-05	.87902E-06	.19925E-06
186599.	.44681E-05	.76675E-06	.15907E-06
191384.	.42560E-05	.65879E-06	.12518E-06
196168.	.39718E-05	.55710E-06	.97109E-07
200953.	.36253E-05	.46343E-06	.74280E-07
205737.	.32337E-05	.37915E-06	.56041E-07
210522.	.28182E-05	.30508E-06	.41721E-07
215307.	.24004E-05	.24149E-06	.30663E-07
220091.	.19995E-05	.18813E-06	.22260E-07
224876.	.16305E-05	.14431E-06	.15970E-07
229660.	.13029E-05	.10907E-06	.11330E-07
234445.	.10214E-05	.81276E-07	.79532E-08
239229.	.78645E-06	.59752E-07	.55266E-08
244014.	.59544E-06	.43370E-07	.38039E-08
248799.	.44377E-06	.31101E-07	.25946E-08
253583.	.32591E-06	.22049E-07	.17547E-08
258368.	.23609E-06	.15464E-07	.11772E-08
263152.	.16884E-06	.10736E-07	.78377E-09
267937.	.11931E-06	.73823E-08	.51809E-09
272722.	.83378E-07	.50307E-08	.34015E-09
277506.	.57660E-07	.33991E-08	.22190E-09
282291.	.39488E-07	.22784E-08	.14389E-09
287075.	.26798E-07	.15157E-08	.92767E-10
291860.	.18031E-07	.10012E-08	.59486E-10

Table 8-SP.. (cont'd) Sample Problem 3 Output

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	NP237	U233	TH229
296545.	.12035E-07	.65888E-09	.37951E-10
301429.	.79728E-08	.42827E-09	.24094E-10
306214.	.52446E-08	.27755E-09	.15227E-10
310998.	.34271E-08	.17886E-09	.95814E-11
315783.	.22255E-08	.11465E-09	.60041E-11
320567.	.14368E-08	.73117E-10	.37477E-11
325352.	.92242E-09	.46408E-10	.23306E-11
330137.	.58911E-09	.29322E-10	.14443E-11
334921.	.37439E-09	.18447E-10	.89198E-12
339706.	.23682E-09	.11558E-10	.54913E-12
344490.	.14914E-09	.72140E-11	.33704E-12
349275.	.93527E-10	.44860E-11	.20626E-12
354060.	.58421E-10	.27798E-11	.12588E-12

OPTIONS 1,0 2,0 3,0 4,0 5,0 6,1 7,1 8,0 9,0 10,0 11,0 12,1 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0

NO OF VECTORS = 0 TIME UPPER BOUND = 3.50E+05

THE SPACE STEP**************** DX = 1.14281E+03 FT
THE TIME STEP***************** DT = 4.78459E+03 Y
NO OF SOURCE BLKS************ NSB = 1

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER
NP237	(DECAY)	.23885E+00	.99845E+00	.10309E+01
U233	(DECAY)	.13694E+01	.97974E+00	.59105E+01
U233	NP237	.80413E+00	.15328E-02	.34707E+01
TH229	(DECAY)	.20689E+01	.63489E+00	.89295E+01
TH229	U233	.17192E+01	.16273E-01	.74200E+01

Table 8-SP. (cont'd) Sample Problem 3 Output

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	NP237	U233	TH229
9569.	0.	0.	.31058E-06
14354.	0.	.53136E-06	.33175E-05
19138.	0.	.31230E-05	.61285E-05
23923.	0.	.48601E-05	.71456E-05
28708.	0.	.53037E-05	.73767E-05
33492.	0.	.54554E-05	.74856E-05
38277.	.46603E-13	.55818E-05	.75814E-05
43061.	.59527E-11	.57073E-05	.76710E-05
47846.	.13233E-09	.58330E-05	.77544E-05
52530.	.12398E-08	.59589E-05	.78308E-05
57415.	.67781E-08	.60852E-05	.78999E-05
62200.	.25545E-07	.62116E-05	.79614E-05
66984.	.73316E-07	.63376E-05	.80151E-05
71769.	.17102E-06	.64620E-05	.80609E-05
76553.	.33925E-06	.65830E-05	.80991E-05
81338.	.59141E-06	.66985E-05	.81301E-05
86123.	.92874E-06	.68061E-05	.81544E-05
90907.	.13393E-05	.69038E-05	.81728E-05
95692.	.18008E-05	.69901E-05	.81861E-05
100476.	.22853E-05	.70641E-05	.81951E-05
105261.	.27651E-05	.71256E-05	.81700E-05
110046.	.32167E-05	.71226E-05	.76001E-05
114830.	.36233E-05	.64294E-05	.46408E-05
119615.	.39751E-05	.39692E-05	.20237E-05
124399.	.42690E-05	.23962E-05	.10900E-05
129184.	.45066E-05	.20041E-05	.87249E-06
133968.	.46933E-05	.18704E-05	.76571E-06
138753.	.48358E-05	.17551E-05	.67098E-06
143538.	.49417E-05	.16374E-05	.58203E-06
148322.	.50180E-05	.15171E-05	.49914E-06
153107.	.50700E-05	.13946E-05	.42274E-06
157891.	.50995E-05	.12705E-05	.35325E-06
162676.	.51018E-05	.11453E-05	.29098E-06
167461.	.50644E-05	.10199E-05	.23612E-06
172245.	.49700E-05	.89568E-06	.18866E-06
177030.	.48012E-05	.77451E-06	.14838E-06
181814.	.45477E-05	.65860E-06	.11488E-06
186599.	.42107E-05	.55024E-06	.87569E-07
191384.	.38033E-05	.45143E-06	.65743E-07
196168.	.33484E-05	.36363E-06	.48634E-07
200953.	.28731E-05	.28764E-06	.35471E-07
205737.	.24041E-05	.22352E-06	.25523E-07
210522.	.19638E-05	.17075E-06	.18130E-07
215307.	.15679E-05	.12830E-06	.12722E-07
220091.	.12252E-05	.94913E-07	.88250E-08
224876.	.93841E-06	.69180E-07	.60558E-08
229660.	.70542E-06	.49724E-07	.41133E-08
234445.	.52116E-06	.35273E-07	.27673E-08
239229.	.37889E-06	.24715E-07	.18450E-08
244014.	.27138E-06	.17118E-07	.12198E-08
248799.	.19171E-06	.11728E-07	.80005E-09
253583.	.13371E-06	.79542E-08	.52086E-09
258368.	.92152E-07	.53436E-08	.33674E-09
263152.	.62817E-07	.35580E-08	.21628E-09
267937.	.42384E-07	.23494E-08	.13806E-09
272722.	.28327E-07	.15393E-08	.87615E-10
277506.	.18765E-07	.10012E-08	.55301E-10
282291.	.12329E-07	.64669E-09	.34727E-10
287075.	.80377E-08	.41503E-09	.21701E-10
291860.	.52027E-08	.26475E-09	.13500E-10

Table 8-SP. (cont'd) Sample Problem 3 Output

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	NP237	U233	TH229
296645.	.33450E-08	.16493E-09	.83618E-11
301429.	.21371E-08	.10594E-09	.51583E-11
306214.	.13574E-08	.66499E-10	.31699E-11
310998.	.85738E-09	.41542E-10	.19409E-11
315783.	.53873E-09	.25836E-10	.11843E-11
320567.	.33686E-09	.15999E-10	.72030E-12
325352.	.20966E-09	.98683E-11	.43673E-12
330137.	.12993E-09	.60636E-11	.26402E-12
334921.	.80189E-10	.37124E-11	.15917E-12
339705.	.49299E-10	.22652E-11	.95704E-13
344490.	.30198E-10	.13777E-11	.57399E-13
349275.	.18433E-10	.83537E-12	.34343E-13
354060.	.11215E-10	.50505E-12	.20501E-13

Table 8-SP. (cont'd) Sample Problem 3 Output

DVM / STC

New Right Hand Page

Notebook Divider Should Read: S.P. 4- Different Release Scenario, etc.

Sample Problem 4: Different Release Scenario , Longer Decay Chain, Solubility Limits

Sample problem 4 simulates a different release scenario and transports a longer decay chain than problems 1-3. The use of solubility limits is also described.

Release is assumed to occur due to a single 13.5 inch diameter borehole connecting the upper and lower aquifer through the depository. Legs 10 and 12 are used in this instance. Water from the borehole is assumed to circulate through the entire depository. Thus, the migration path is assumed to begin at the center of leg 13. However, to assure that the fluid flow rate in the borehole is used in all source calculations, we flag leg 12 negatively on the migration path card.

The decay chain

```
CM246 ───►PU242───►U238───►U234───►TH230───►RA226
                              ↑
                            PU238
```

is transported along legs 13, 12, 7, 8 and 15.

Input is described in terms of changes to the base-case (Table 9-SP).

BC(1) A different title

SAMPLE PROBLEM NO. 4

BC(2) A blank card is inserted.

BC(4) Conductivity in legs 10, 12 and 13 is set to 10 ft/day.

BC(5) The cross-sectional area of leg 13 is set to 2.7 x 10^4 ft^2. That is

$$AREA(13) = 6000 \times 18 \times .25$$

where depository width is 6000ft, height is 18 ft, and there is a .25 extraction ratio. (.25 extraction ratio implies that 25/100 of the intact salt is removed to create depository rooms, corridors, etc.)

BC(8) Porosity in legs 10 and 12 is set to 0.15 and leg 13 is set to .1.

BC(9) The brine concentration in leg 10 is set to .67.

BC(10) The migration path card becomes

5 13 -12 7 8 15.

BC(12) The number of isotopes is 7. Decay chain information includes:

Name	Component	Half-Life (years)	Curies
CM246	1	4.71×10^3	3.22×10^4
PU242	2	3.79×10^5	1.28×10^3
U238	3	4.51×10^9	106
PU238	4	89	1.11×10^7
U234	5	2.47×10^5	789
TH230	6	8×10^4	1.74
RA226	7	1600	.014

The initial curies are from the Blomeke low-growth projections.* Each parent-to-daughter decay fraction is one. Finally note that U234 has 2 parents and PU238 has none.

BC(13) Legs 7, 8 and 15 (the 3rd, 4th, and 5th legs in the migration path) are assigned the KD's given below. KD's in legs 13 and 12 remain zero.

Isotope	KD(ft/lb)
CM246	5.20
PU242	.96
U238	.15
PU238	.96
U234	.15
TH230	7.35
RA226	.02

Although these numbers may appear somewhat strange, they arise from a random sampling technique over reasonable KD ranges.

BC(15) The LLONLY parameter on the DVM control card is set to 2. The model logic is then to test at each time step whether an isotope ought to be solubility- or leach-limited.

BC(16) The solubility limits card is written in 7E10.3 format.

*Blomeke, J. O. and Kee, C. W., Projections of Wastes to be Generated, International Symposium on the Management of Wastes from the LWR Fuel Cycle, Denver, Co., July 11-16, 1976.

Isotope	Solubility Limit (g/g)
CM246	10.
PU242	1.55×10^{-13}
U238	2.57×10^{-5}
PU238	4.54×10^{-13}
U234	5.14×10^{-8}
TH230	5.35×10^{-8}
RA226	6.74×10^{-9}

Except for CM246 these values are also the result of a random sampling technique. Since CM is assumed to have unlimited solubility, the value 10 g/g is inserted to force a leach-limited source. Notice that for example, U238 and U234 have different limits. The solubility limit 2.57×10^{-5} was sampled for uranium and then multiplied by an average mass fraction, i.e., .998 for U238 and .002 for U234.

The time dependent discharge rates are graphed on Figure 8-SP. Since solubility limits are utilized and the decay chain consists of more than 3 isotopes we can no longer use GETOUT for comparison. Hence, SWIFT was used for comparison and its output is depicted at various times. The early pulse of PU242 is caused by the decay of slowly moving CM246 outside the depository region. Solubility limits are not tested outside the depository due to the large volume of water in the aquifers. The effect of CM246 decay diminishes after a few half-lives. The output pulse of PU242 then shows the effect of a solubility-limited source. Code output is given in Table 10-SP.

Table 9-SP. Sample Problem 4 Input Data

```
SAMPLE PROBLEM NO. 4                                                                            BC  1
 432.70   646.10   432.70                                                                       BC  2
   50.0     50.0     50.0     50.0     40.0     40.0     40.0     40.0                          BC  3
 1.5E-6      10.  1.67E-6      10.      10.  1.57E-6      2.5                                   BC  4
   6.E6     6.E6     6.E6     6.E6    1.8E6    1.8E6    1.8E6    1.8E6                          BC  4
     1.      1.0       1.      1.0    2.7E4       1.    1.2E8                                   BC  5
 14500.    8000.   38000.  100000.   14500.    8000.   38000.  100000.                          BC  5
   600.    496.5     500.    603.5    8000.    1100.    1100.                                   BC  6
3602.41  2502.41  1525.89  3414.81  3311.31  2814.81  2814.81  2314.81                          BC  6
2211.31  2819.67  1719.67   425.89                                                              BC  7
     .3       .3       .3       .3       .3       .3       .3       .3                          BC  7
    .03      .15      .03      .15       .1      .03       .3       .3                          BC  8
     0.       0.       0.       0.       0.       0.       .3       0.                          BC  8
     1.      .67       1.       1.       1.       1.       0.                                   BC  9
 5   13  -12    7    8   15                                                                     BC  9
 7                                                                                              BC 10
   246.    CM246        1        0    4710.   3.22E4                                            BC 12
   242.    PU242        2        1   3.79E5   1.28E3                                            BC 12
      1       1.                                                                                BC 12
   238.     U238        3        1   4.51E9     106.                                            BC 12
      2       1.                                                                                BC 12
   238.    PU238        4        0      89.   1.11E7                                            BC 12
   234.     U234        5        2   2.47E5     789.                                            BC 12
      3       1.                                                                                BC 12
      4       1.                                                                                BC 12
   230.    TH230        6        1     8.E4     1.74                                            BC 12
      5       1.                                                                                BC 12
   226.    RA226        7        1    1600.     .014                                            BC 12
      6       1.                                                                                BC 12
                     5.20     5.20     5.20                                                     BC 12
                      .96      .96      .96                                                     BC 13
                      .15      .15      .15                                                     BC 13
                      .96      .96      .96                                                     BC 13
                      .15      .15      .15                                                     BC 13
                     7.35     7.35     7.35                                                     BC 13
                      .02      .02      .02                                                     BC 13
   1.E5     500.                                                                                BC 13
 2                                                                                              BC 14
    10. 1.55E-13  2.57E-5 4.54E-13  5.14E-8  5.35E-8  6.78E-9                                   BC 15
                                                                                                BC 16
                                                                                                BC 18
```

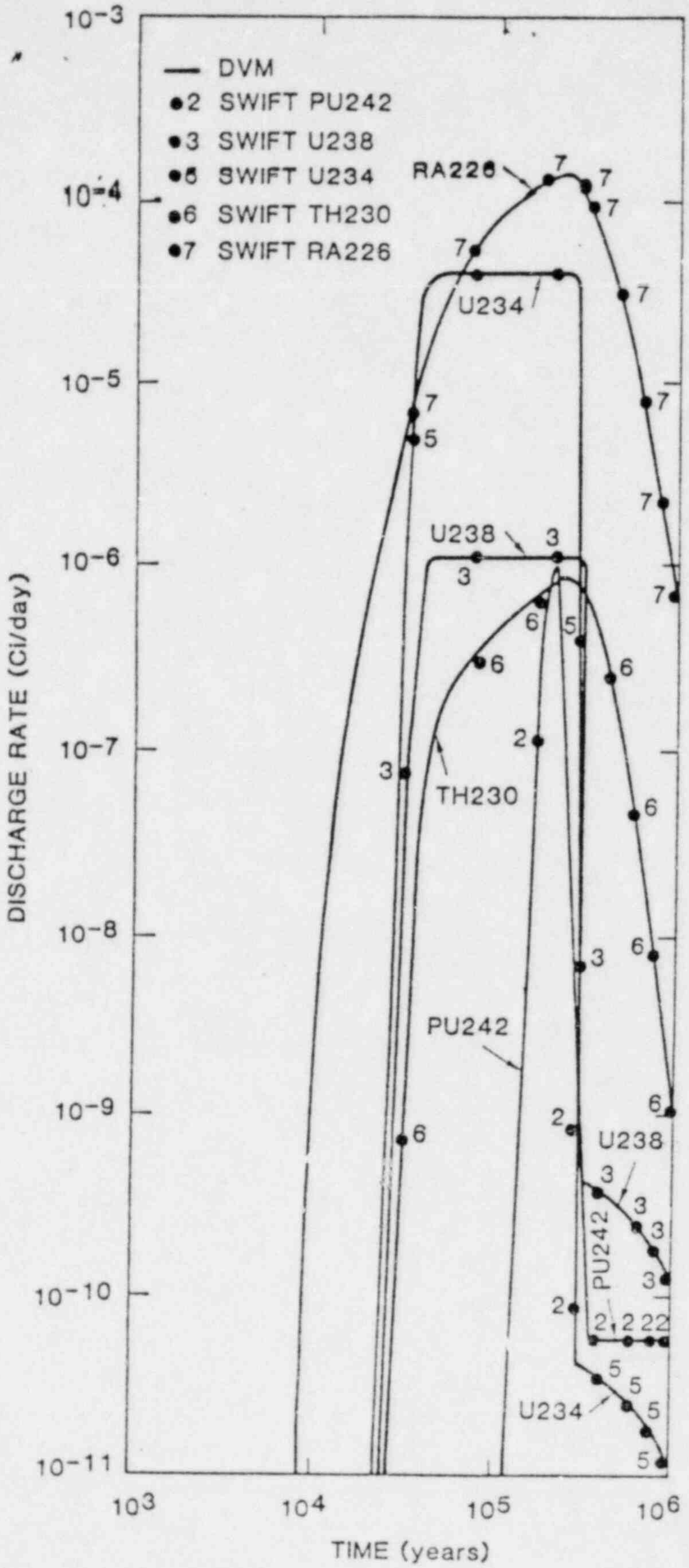


Figure 8-SP. Discharge Rates vs. Time for Problem 4

SAMPLE PROBLEM NO. 4

OPTIONS 1,0 2,0 3,0 4,0 5,0 6,0 7,0 8,0 9,0 10,0 11,0 12,0 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0

NUMBER OF ISOTOPES 7

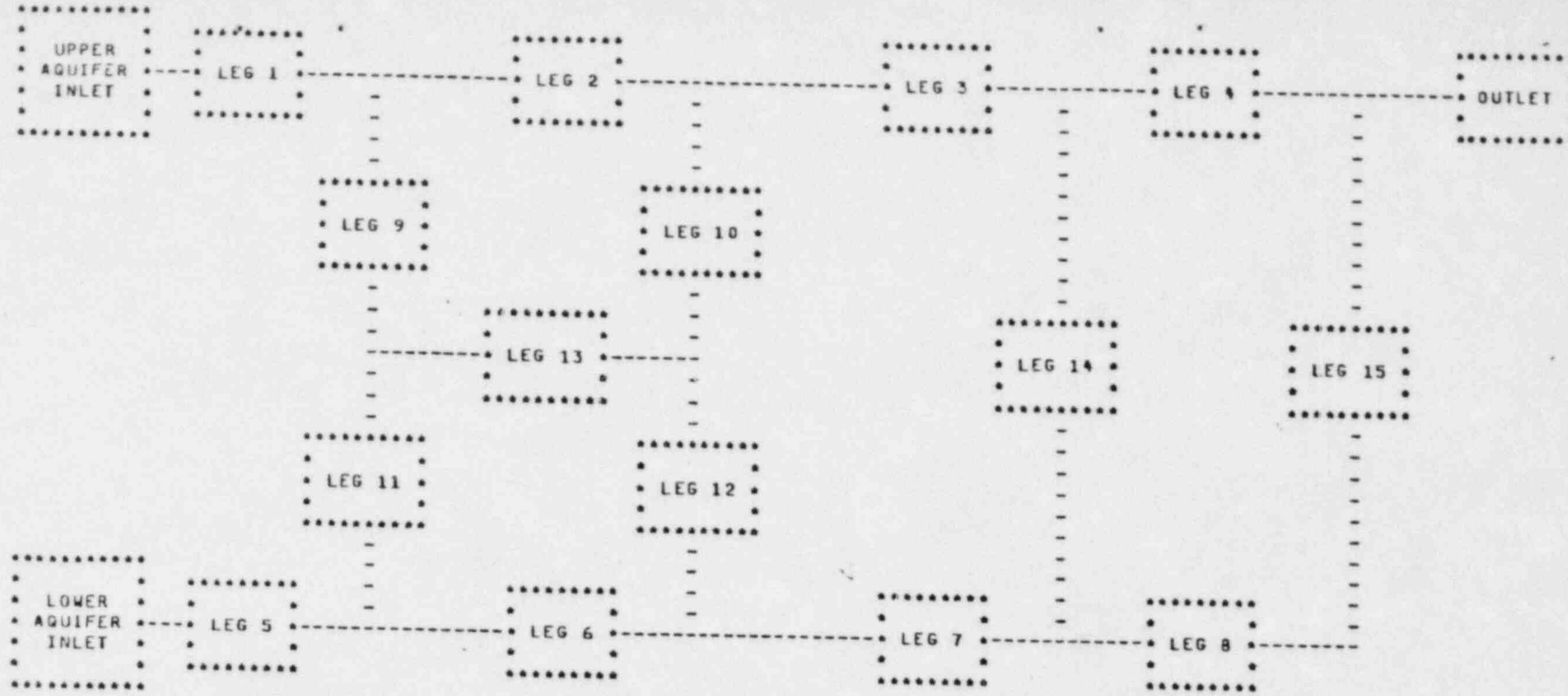
ISOTOPE NAME	HALF LIFE (YEARS)	INITIAL AMOUNT (CI)
CM246	4.710E+03	3.220E+04
PU242	3.790E+05	1.280E+03
U238	4.510E+09	1.060E+02
PU238	8.900E+01	1.110E+07
U234	2.470E+05	7.890E+02
TH230	8.000E+04	1.740E+00
RA226	1.600E+03	1.400E-02

LEACH TIME = 1.000E+05 YEARS DISPERSIVITY = 5.000E+02 FEET

NO OF VECTORS = 0 TIME UPPER BOUND = 1.00E+06

Table 10-SP. Sample Problem 4 Output
(Pages 146 through 161 inclusive)

NETWORK FLOW MODEL



------RADIONUCLIDE MIGRATION PATH------LEGS 13 -12 7 8 15

UPPER AQUIFER INLET
INLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 3602.41 FT

LOWER AQUIFER INLET
INLET PRESSURE = 93038.40 LB/FT**2
ELEVATION = 2502.41 FT

OUTLET
OUTLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 1525.89 FT

ELEVATIONS OF OTHER POINTS

JUNCTION 4 (LEGS 1-2-9) =	3414.81 FT
JUNCTION 5 (LEGS 2-3-10) =	3311.31 FT
JUNCTION 6 (LEGS 9-11-13) =	2814.81 FT
JUNCTION 7 (LEGS 10-12-13) =	2814.81 FT
JUNCTION 8 (LEGS 5-6-11) =	2314.81 FT
JUNCTION 9 (LEGS 6-7-12) =	2211.31 FT
JUNCTION10 (LEGS 3-4-14) =	2819.67 FT
JUNCTION11 (LEGS 7-8-14) =	1719.67 FT
JUNCTION12 (LEGS 8-15) =	425.89 FT

LEG PROPERTIES

LEG 1
LENGTH = 1.45E+04 FT
AREA = 6.00E+06 FT**2

```
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  2
********
          LENGTH =  8.00E+03 FT
            AREA =  6.00E+06 FT**2
    CONDUCTIVITY =  1.83E+04 FT/YR
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  3
********
          LENGTH =  3.80E+04 FT
            AREA =  6.00E+06 FT**2
    CONDUCTIVITY =  1.83E+04 FT/YR
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  4
********
          LENGTH =  1.00E+05 FT
            AREA =  6.00E+06 FT**2
    CONDUCTIVITY =  1.83E+04 FT/YR
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  5
********
          LENGTH =  1.45E+04 FT
            AREA =  1.80E+06 FT**2
    CONDUCTIVITY =  1.46E+04 FT/YR
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  6
********
          LENGTH =  8.00E+03 FT
            AREA =  1.80E+06 FT**2
    CONDUCTIVITY =  1.46E+04 FT/YR
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  7
********
          LENGTH =  3.80E+04 FT
            AREA =  1.80E+06 FT**2
    CONDUCTIVITY =  1.46E+04 FT/YR
        POROSITY =    .3000
    ROCK DENSITY =  1.19E+02 LB/FT**3
   FLUID DENSITY =  6.23E+01 LB/FT**3
 FLUID VISCOSITY =  1.00E+00 CP
```

```
LEG  8           LENGTH =  1.00E+05 FT
********           AREA =  1.80E+06 FT**2
           CONDUCTIVITY =  1.46E+04 FT/YR
               POROSITY =   .3000
           ROCK DENSITY =  1.19E+02 LB/FT**3
          FLUID DENSITY =  6.23E+01 LB/FT**3
        FLUID VISCOSITY =  1.00E+00 CP

                 LEG PROPERTIES

LEG  9           LENGTH =  6.00E+02 FT
********           AREA =  1.00E+00 FT**2
           CONDUCTIVITY =  5.48E-04 FT/YR
               POROSITY =   .0300
           ROCK DENSITY =  1.65E+02 LB/FT**3
          FLUID DENSITY =  7.40E+01 LB/FT**3
        FLUID VISCOSITY =  1.43E+00 CP

                 LEG PROPERTIES

LEG 10           LENGTH =  4.97E+02 FT
********           AREA =  1.00E+00 FT**2
           CONDUCTIVITY =  3.65E+03 FT/YR
               POROSITY =   .1500
           ROCK DENSITY =  1.45E+02 LB/FT**3
          FLUID DENSITY =  7.02E+01 LB/FT**3
        FLUID VISCOSITY =  1.27E+00 CP

                 LEG PROPERTIES

LEG 11           LENGTH =  5.00E+02 FT
********           AREA =  1.00E+00 FT**2
           CONDUCTIVITY =  6.10E-04 FT/YR
               POROSITY =   .0300
           ROCK DENSITY =  1.65E+02 LB/FT**3
          FLUID DENSITY =  7.40E+01 LB/FT**3
        FLUID VISCOSITY =  1.43E+00 CP

                 LEG PROPERTIES

LEG 12           LENGTH =  6.04E+02 FT
********           AREA =  1.00E+00 FT**2
           CONDUCTIVITY =  3.65E+03 FT/YR
               POROSITY =   .1500
           ROCK DENSITY =  1.45E+02 LB/FT**3
          FLUID DENSITY =  7.40E+01 LB/FT**3
        FLUID VISCOSITY =  1.43E+00 CP

                 LEG PROPERTIES

LEG 13           LENGTH =  8.00E+03 FT
********           AREA =  2.70E+04 FT**2
           CONDUCTIVITY =  3.65E+03 FT/YR
               POROSITY =   .1000
           ROCK DENSITY =  1.53E+02 LB/FT**3
          FLUID DENSITY =  7.40E+01 LB/FT**3
        FLUID VISCOSITY =  1.43E+00 CP

                 LEG PROPERTIES

LEG 14           LENGTH =  1.10E+03 FT
********           AREA =  1.00E+00 FT**2
           CONDUCTIVITY =  5.73E-04 FT/YR
               POROSITY =   .0300
```

FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 15
****

LENGTH = 1.10E+03 FT
AREA = 1.20E+08 FT**2
CONDUCTIVITY = 9.13E+02 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

DISTRIBUTION COEFFICIENTS BY LEG AND BY ISOTOPE

	CM246	PU242	U238	PU238	U234	TH230	RA226
LEG13	0.	0.	0.	0.	0.	0.	0.
LEG12	0.	0.	0.	0.	0.	0.	0.
LEG 7	.52000E+01	.96000E+00	.15000E+00	.96000E+00	.15000E+00	.73500E+01	.20000E-01
LEG 8	.52000E+01	.96000E+00	.15000E+00	.96000E+00	.15000E+00	.73500E+01	.20000E-01
LEG15	.52000E+01	.96000E+00	.15000E+00	.96000E+00	.15000E+00	.73500E+01	.20000E-01

RETARDATION FACTORS BY LEG AND BY ISOTOPE

	CM246	PU242	U238	PU238	U234	TH230	RA226
LEG13	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
LEG12	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
LEG 7	.20637E+04	.38180E+03	.60500E+02	.38180E+03	.60500E+02	.29165E+04	.89333E+01
LEG 8	.20637E+04	.38180E+03	.60500E+02	.38180E+03	.60500E+02	.29165E+04	.89333E+01
LEG15	.20637E+04	.38180E+03	.60500E+02	.38180E+03	.60500E+02	.29165E+04	.89333E+01

LEG NO.	FLOW VOL. (CU FT)/DAY	DARCY VEL. FT/DAY	PORE VEL. FT/DAY
1	3.88E+06	6.47E-01	2.16E+00
2	3.88E+06	6.47E-01	2.16E+00
3	3.88E+06	6.47E-01	2.16E+00
4	3.88E+06	6.47E-01	2.16E+00
5	6.58E+05	3.66E-01	1.22E+00
6	6.58E+05	3.66E-01	1.22E+00
7	6.58E+05	3.66E-01	1.22E+00
8	6.58E+05	3.66E-01	1.22E+00
9	-7.85E-07	-7.85E-07	-2.62E-05
10	-4.67E+00	-4.67E+00	-3.11E+01
11	-7.25E-07	-7.25E-07	-2.42E-05
12	-4.67E+00	-4.67E+00	-3.11E+01
13	6.02E-08	2.23E-12	2.23E-11
14	-5.83E-07	-5.83E-07	-1.94E-05
15	6.58E+05	5.48E-03	1.83E-02

TOTAL PATH LENGTH (FT) = 1.4770E+05
FROM DEPOSITORY MIDPT (FT) = 1.4370E+05
AVERAGE FLUID VELOCITY (FT/Y) = 2.1095E+01

THE SPACE STEP............... DX = 1.35147E+03 FT
THE TIME STEP................ DT = 1.76528E+03 Y
NO OF SOURCE BLKS............ NSB = 5

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER

[illegible]	(DECAY)	.14565E+00	.77122E+00	.19148E+00
PU242	(DECAY)	.76559E+00	.99678E+00	.10055E+01
PU242	CM246	.45562E+00	.22840E+00	.59898E+00
U238	(DECAY)	.40969E+01	.10000E+01	.53860E+01
U238	PU242	.24312E+01	.32233E-02	.31962E+01
U238	PU242 CM246	.16694E+01	.38486E-03	.21947E+01
PU238	(DECAY)	.76559E+00	.10696E-05	.10065E+01
U234	(DECAY)	.40969E+01	.99506E+00	.53860E+01
U234	U238	.40969E+01	.27064E-06	.53860E+01
U234	U238 PU242	.29864E+01	.43676E-09	.39262E+01
U234	PU238	.38546E+01	.99542E+00	.50674E+01
TH230	(DECAY)	.10325E+00	.98482E+00	.13574E+00
TH230	U234	.21001E+01	.49040E-02	.27609E+01
RA226	(DECAY)	.13582E+02	.46545E+00	.17855E+02
RA226	TH230	.68424E+01	.10599E-01	.89955E+01
RA226	TH230 U234	.59272E+01	.29611E-04	.77923E+01

YEAR	CM246	PU242	U238	PU238	U234	TH230	RA226
3531.	0.	0.	0.	0.	0.	0.	0.
5296.	0.	0.	0.	0.	0.	0.	0.
7061.	0.	0.	0.	0.	0.	0.	0.
8826.	0.	0.	0.	0.	0.	0.	0.
10592.	0.	0.	0.	0.	0.	0.	.73280E-11
12357.	0.	0.	0.	0.	0.	0.	.12677E-08
14122.	0.	0.	0.	0.	0.	0.	.20975E-07
15887.	0.	0.	0.	0.	0.	0.	.84597E-07
17653.	0.	0.	0.	0.	0.	0.	.19411E-06
19418.	0.	0.	0.	0.	0.	0.	.35165E-06
21183.	0.	0.	.76357E-20	0.	0.	0.	.56298E-06
22949.	0.	0.	.15874E-14	0.	.26770E-18	.67932E-23	.83751E-06
24714.	0.	0.	.13299E-11	0.	.55404E-13	.53965E-17	.11890E-05
26479.	0.	0.	.11491E-09	0.	.46211E-10	.66902E-14	.16373E-05
28244.	0.	0.	.25818E-08	0.	.39750E-08	.73437E-12	.22103E-05
30010.	0.	0.	.23198E-07	0.	.88925E-07	.20369E-10	.29491E-05
31775.	0.	0.	.10684E-06	0.	.79564E-06	.23149E-09	.39104E-05
33540.	0.	0.	.29766E-06	0.	.36498E-05	.13963E-08	.51560E-05
35306.	0.	0.	.56846E-06	0.	.10132E-04	.52296E-08	.67208E-05
37071.	0.	0.	.82560E-06	0.	.19288E-04	.13606E-07	.85749E-05
38836.	0.	0.	.99829E-06	0.	.27943E-04	.26926E-07	.10629E-04
40601.	0.	0.	.10840E-05	0.	.33727E-04	.43720E-07	.12784E-04
42367.	0.	0.	.11165E-05	0.	.36585E-04	.61923E-07	.14973E-04
44132.	0.	0.	.11263E-05	0.	.37665E-04	.80097E-07	.17162E-04
45897.	0.	0.	.11287E-05	0.	.37988E-04	.97040E-07	.19339E-04
47662.	0.	0.	.11292E-05	0.	.38066E-04	.11444E-06	.21503E-04
49428.	0.	0.	.11293E-05	0.	.38082E-04	.13055E-06	.23653E-04
51193.	0.	0.	.11293E-05	0.	.38085E-04	.14608E-06	.25790E-04
52958.	0.	0.	.11293E-05	0.	.38085E-04	.16108E-06	.27912E-04
54724.	0.	0.	.11293E-05	0.	.38085E-04	.17563E-06	.30021E-04
56489.	0.	0.	.11293E-05	0.	.38085E-04	.18977E-06	.32116E-04
58254.	0.	0.	.11293E-05	0.	.38085E-04	.20354E-06	.34198E-04
60019.	0.	0.	.11293E-05	0.	.38085E-04	.21697E-06	.36266E-04
61785.	0.	0.	.11293E-05	0.	.38085E-04	.23009E-06	.38322E-04
63550.	0.	0.	.11293E-05	0.	.38085E-04	.24291E-06	.40364E-04
65315.	0.	0.	.11293E-05	0.	.38085E-04	.25546E-06	.42393E-04
67080.	0.	0.	.11293E-05	0.	.38085E-04	.26775E-06	.44408E-04
68846.	0.	0.	.11293E-05	0.	.38085E-04	.27978E-06	.46411E-04
70511.	0.	0.	.11293E-05	0.	.38085E-04	.29158E-06	.48401E-04
72376.	0.	0.	.11293E-05	0.	.38085E-04	.30316E-06	.50377E-04
74142.	0.	0.	.11293E-05	0.	.38085E-04	.31451E-06	.52340E-04
75907.	0.	0.	.11293E-05	0.	.38085E-04	.32566E-06	.54290E-04
77672.	0.	0.	.11293E-05	0.	.38085E-04	.33660E-06	.56227E-04
79437.	0.	0.	.11293E-05	0.	.38085E-04	.34735E-06	.58151E-04
81203.	0.	0.	.11293E-05	0.	.38085E-04	.35791E-06	.60061E-04
82968.	0.	0.	.11293E-05	0.	.38085E-04	.36828E-06	.61959E-04
84733.	0.	0.	.11293E-05	0.	.38085E-04	.37847E-06	.63843E-04
86499.	0.	0.	.11293E-05	0.	.38085E-04	.38849E-06	.65714E-04
88264.	0.	.51854E-25	.11293E-05	0.	.38085E-04	.39834E-06	.67572E-04
90029.	0.	.59104E-24	.11293E-05	0.	.38085E-04	.40802E-06	.69417E-04
91794.	0.	.58480E-23	.11293E-05	0.	.38085E-04	.41754E-06	.71248E-04
93560.	0.	.50804E-22	.11293E-05	0.	.38085E-04	.42690E-06	.73067E-04
95325.	0.	.39142E-21	.11293E-05	0.	.38085E-04	.43611E-06	.74872E-04
97090.	0.	.26984E-20	.11293E-05	0.	.38085E-04	.44517E-06	.76664E-04
98855.	0.	.16777E-19	.11293E-05	0.	.38085E-04	.45407E-06	.78443E-04
100621.	0.	.94748E-19	.11293E-05	0.	.38085E-04	.46283E-06	.80209E-04
102386.	0.	.48912E-18	.11293E-05	0.	.38085E-04	.47145E-06	.81962E-04
104151.	0.	.23215E-17	.11293E-05	0.	.38085E-04	.47993E-06	.83701E-04
105917.	0.	.10183E-16	.11293E-05	0.	.38085E-04	.48828E-06	.85427E-04
107682.	0.	.41482E-16	.11293E-05	0.	.38085E-04	.50457E-06	.88837E-04

YEAR	CM246	PU242	U238	PU238	U234	TH230	RA226
109447.	0.	.15760E-15	.11293E-05	0.	.38085E-04	.51251E-06	.90337E-04
111213.	0.	.56071E-15	.11293E-05	0.	.38085E-04	.52034E-06	.91415E-04
112978.	0.	.18749E-14	.11293E-05	0.	.38085E-04	.52803E-06	.92393E-04
114743.	0.	.59118E-14	.11293E-05	0.	.38085E-04	.53561E-06	.93477E-04
116508.	0.	.17634E-13	.11293E-05	0.	.38085E-04	.54306E-06	.94542E-04
118273.	0.	.49900E-13	.11293E-05	0.	.38085E-04	.55040E-06	.95584E-04
120039.	0.	.13432E-12	.11293E-05	0.	.38085E-04	.55762E-06	.96604E-04
121804.	0.	.34478E-12	.11293E-05	0.	.38085E-04	.56473E-06	.97602E-04
123569.	0.	.84591E-12	.11293E-05	0.	.38085E-04	.57172E-06	.98578E-04
125335.	0.	.19879E-11	.11293E-05	0.	.38085E-04	.57861E-06	.99533E-04
127100.	0.	.44840E-11	.11293E-05	0.	.38085E-04	.58539E-06	.10047E-03
128865.	0.	.97259E-11	.11293E-05	0.	.38085E-04	.59206E-06	.10138E-03
130630.	0.	.20322E-10	.11293E-05	0.	.38085E-04	.59862E-06	.10227E-03
132396.	0.	.40970E-10	.11293E-05	0.	.38085E-04	.60509E-06	.10315E-03
134161.	0.	.79826E-10	.11293E-05	0.	.38085E-04	.61145E-06	.10400E-03
135926.	0.	.15053E-09	.11293E-05	0.	.38085E-04	.61771E-06	.10483E-03
137692.	0.	.27510E-09	.11293E-05	0.	.38085E-04	.62387E-06	.10565E-03
139457.	0.	.48790E-09	.11293E-05	0.	.38085E-04	.62994E-06	.10644E-03
141222.	0.	.84073E-09	.11293E-05	0.	.38085E-04	.63592E-06	.10722E-03
142987.	0.	.14093E-08	.11293E-05	0.	.38085E-04	.64180E-06	.10798E-03
144753.	0.	.23004E-08	.11293E-05	0.	.38085E-04	.64759E-06	.10872E-03
146518.	0.	.36606E-08	.11293E-05	0.	.38085E-04	.65329E-06	.10944E-03
148283.	0.	.56840E-08	.11293E-05	0.	.38085E-04	.65890E-06	.11015E-03
150048.	0.	.86205E-08	.11293E-05	0.	.38085E-04	.66442E-06	.11084E-03
151814.	0.	.12781E-07	.11293E-05	0.	.38085E-04	.66985E-06	.11151E-03
153579.	0.	.18540E-07	.11293E-05	0.	.38085E-04	.67521E-06	.11217E-03
155344.	0.	.26336E-07	.11293E-05	0.	.38085E-04	.68048E-06	.11280E-03
157110.	0.	.36660E-07	.11293E-05	0.	.38085E-04	.68566E-06	.11343E-03
158875.	0.	.50044E-07	.11293E-05	0.	.38085E-04	.69077E-06	.11403E-03
160640.	0.	.67043E-07	.11293E-05	0.	.38085E-04	.69580E-06	.11462E-03
162405.	0.	.88201E-07	.11293E-05	0.	.38085E-04	.70075E-06	.11520E-03
164171.	0.	.11402E-06	.11293E-05	0.	.38085E-04	.70562E-06	.11576E-03
165936.	0.	.14494E-06	.11293E-05	0.	.38085E-04	.71042E-06	.11630E-03
167701.	0.	.18125E-06	.11293E-05	0.	.38085E-04	.71514E-06	.11683E-03
169466.	0.	.22313E-06	.11293E-05	0.	.38085E-04	.71979E-06	.11735E-03
171232.	0.	.27053E-06	.11293E-05	0.	.38085E-04	.72437E-06	.11785E-03
172997.	0.	.32323E-06	.11293E-05	0.	.38085E-04	.72887E-06	.11834E-03
174762.	0.	.38074E-06	.11293E-05	0.	.38085E-04	.73331E-06	.11881E-03
176528.	0.	.44238E-06	.11293E-05	0.	.38085E-04	.73768E-06	.11927E-03
178293.	0.	.50722E-06	.11293E-05	0.	.38085E-04	.74198E-06	.11971E-03
180058.	0.	.57417E-06	.11293E-05	0.	.38085E-04	.74621E-06	.12015E-03
181823.	0.	.64194E-06	.11293E-05	0.	.38085E-04	.75038E-06	.12057E-03
183589.	0.	.70916E-06	.11293E-05	0.	.38085E-04	.75448E-06	.12097E-03
185354.	0.	.77439E-06	.11293E-05	0.	.38085E-04	.75852E-06	.12137E-03
187119.	0.	.83620E-06	.11293E-05	0.	.38085E-04	.76250E-06	.12175E-03
188885.	0.	.89319E-06	.11293E-05	0.	.38085E-04	.76641E-06	.12212E-03
190650.	0.	.94412E-06	.11293E-05	0.	.38085E-04	.77027E-06	.12248E-03
192415.	0.	.98786E-06	.11293E-05	0.	.38085E-04	.77406E-06	.12282E-03
194180.	0.	.10235E-05	.11293E-05	0.	.38085E-04	.77780E-06	.12316E-03
195946.	0.	.10505E-05	.11293E-05	0.	.38085E-04	.78148E-06	.12348E-03
197711.	0.	.10683E-05	.11293E-05	0.	.38085E-04	.78510E-06	.12379E-03
199476.	0.	.10767E-05	.11293E-05	0.	.38085E-04	.78867E-06	.12409E-03
201241.	0.	.10760E-05	.11293E-05	0.	.38085E-04	.79218E-06	.12438E-03
203007.	0.	.10663E-05	.11293E-05	0.	.38085E-04	.79564E-06	.12466E-03
204772.	0.	.10483E-05	.11293E-05	0.	.38085E-04	.79904E-06	.12492E-03
206537.	0.	.10226E-05	.11293E-05	0.	.38085E-04	.80239E-06	.12518E-03
208303.	0.	.99004E-06	.11293E-05	0.	.38085E-04	.80569E-06	.12543E-03
210068.	0.	.95158E-06	.11293E-05	0.	.38085E-04	.80894E-06	.12566E-03
211833.	0.	.90821E-06	.11293E-05	0.	.38085E-04	.81213E-06	.12589E-03
213598.	0.	.86094E-06	.11293E-05	0.	.38085E-04	.81528E-06	.12611E-03

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215364.	0.	.81079E-06	.11293E-05	0.	.38085E-04	.81838E-06	.12631E-03
217129.	0.	.75874E-06	.11293E-05	0.	.38085E-04	.82143E-06	.12651E-03
218894.	0.	.70569E-06	.11293E-05	0.	.38085E-04	.82444E-06	.12670E-03
220659.	0.	.65249E-06	.11293E-05	0.	.38085E-04	.82739E-06	.12688E-03
222425.	0.	.59986E-06	.11293E-05	0.	.38085E-04	.83031E-06	.12705E-03
224190.	0.	.54844E-06	.11293E-05	0.	.38085E-04	.83317E-06	.12721E-03
225955.	0.	.49877E-06	.11293E-05	0.	.38085E-04	.83600E-06	.12736E-03
227721.	0.	.45128E-06	.11293E-05	0.	.38085E-04	.83877E-06	.12750E-03
229486.	0.	.40630E-06	.11293E-05	0.	.38085E-04	.84151E-06	.12764E-03
231251.	0.	.36406E-06	.11293E-05	0.	.38085E-04	.84420E-06	.12776E-03
233016.	0.	.32472E-06	.11293E-05	0.	.38085E-04	.84686E-06	.12788E-03
234782.	0.	.28835E-06	.11293E-05	0.	.38085E-04	.84947E-06	.12799E-03
236547.	0.	.25497E-06	.11293E-05	0.	.38085E-04	.85204E-06	.12809E-03
238312.	0.	.22453E-06	.11293E-05	0.	.38085E-04	.85457E-06	.12818E-03
240078.	0.	.19694E-06	.11293E-05	0.	.38085E-04	.85706E-06	.12626E-03
241843.	0.	.17209E-06	.11293E-05	0.	.38085E-04	.85952E-06	.12832E-03
243608.	0.	.14983E-06	.11293E-05	0.	.38085E-04	.86193E-06	.12836E-03
245373.	0.	.12999E-06	.11293E-05	0.	.38085E-04	.86431E-06	.12838E-03
247139.	0.	.11240E-06	.11293E-05	0.	.38085E-04	.86665E-06	.12835E-03
248904.	0.	.96880E-07	.11293E-05	0.	.38085E-04	.86896E-06	.12827E-03
250669.	0.	.83243E-07	.11293E-05	0.	.38085E-04	.87123E-06	.12811E-03
252434.	0.	.71314E-07	.11293E-05	0.	.38082E-04	.87346E-06	.12786E-03
254200.	0.	.60920E-07	.11293E-05	0.	.38011E-04	.87564E-06	.12746E-03
255965.	0.	.51900E-07	.11293E-05	0.	.37410E-04	.87763E-06	.12688E-03
257730.	0.	.44101E-07	.11293E-05	0.	.34926E-04	.87876E-06	.12603E-03
259496.	0.	.37381E-07	.11293E-05	0.	.29077E-04	.87749E-06	.12490E-03
261261.	0.	.31609E-07	.11293E-05	0.	.20409E-04	.87198E-06	.12348E-03
263026.	0.	.26669E-07	.11293E-05	0.	.11714E-04	.86158E-06	.12187E-03
264791.	0.	.22452E-07	.11293E-05	0.	.54805E-05	.84744E-06	.12016E-03
266557.	0.	.18864E-07	.11293E-05	0.	.21493E-05	.83153E-06	.11841E-03
268322.	0.	.15818E-07	.11293E-05	0.	.77552E-06	.81538E-06	.11668E-03
270087.	0.	.13240E-07	.11293E-05	0.	.32402E-06	.79972E-06	.11497E-03
271852.	0.	.11063E-07	.11293E-05	0.	.20065E-06	.78476E-06	.11328E-03
273618.	0.	.92296E-08	.11293E-05	0.	.16952E-06	.77045E-06	.11162E-03
275383.	0.	.76885E-08	.11293E-05	0.	.15958E-06	.75671E-06	.10999E-03
277148.	0.	.63959E-08	.11293E-05	0.	.15374E-06	.74348E-06	.10838E-03
278914.	0.	.53141E-08	.11293E-05	0.	.14857E-06	.73067E-06	.10680E-03
280679.	0.	.44105E-08	.11293E-05	0.	.14350E-06	.71825E-06	.10524E-03
282444.	0.	.36570E-08	.11292E-05	0.	.13845E-06	.70618E-06	.10371E-03
284209.	0.	.30299E-08	.11285E-05	0.	.13334E-06	.69442E-06	.10220E-03
285975.	0.	.25088E-08	.11215E-05	0.	.12775E-06	.68295E-06	.10071E-03
287740.	0.	.20766E-08	.10850E-05	0.	.11976E-06	.67175E-06	.99244E-04
289505.	0.	.17185E-08	.97446E-06	0.	.10549E-06	.66080E-06	.97800E-04
291271.	0.	.14224E-08	.76358E-06	0.	.82344E-07	.65007E-06	.96377E-04
293036.	0.	.11778E-08	.49632E-06	0.	.54058E-07	.63955E-06	.94975E-04
294801.	0.	.97599E-09	.26053E-06	0.	.28935E-07	.62924E-06	.93594E-04
296566.	0.	.80978E-09	.10980E-06	0.	.12504E-07	.61912E-06	.92233E-04
298332.	0.	.67301E-09	.37518E-07	0.	.43906E-08	.60919E-06	.90893E-04
300097.	0.	.56060E-09	.10703E-07	0.	.12833E-08	.59945E-06	.89573E-04
301862.	0.	.46831E-09	.27928E-08	0.	.33619E-09	.58990E-06	.88272E-04
303627.	0.	.39263E-09	.88863E-09	0.	.10064E-09	.58052E-06	.86992E-04
305393.	0.	.33062E-09	.50436E-09	0.	.51582E-10	.57131E-06	.85730E-04
307158.	0.	.27986E-09	.43689E-09	0.	.42730E-10	.56226E-06	.84488E-04
308923.	0.	.23836E-09	.42546E-09	0.	.41230E-10	.55338E-06	.83264E-04
310689.	0.	.20444E-09	.42271E-09	0.	.40903E-10	.54465E-06	.82058E-04
312454.	0.	.17676E-09	.421[illegible]7E-09	0.	.40746E-10	.53608E-06	.80871E-04
314219.	0.	.15418E-09	.41979E-09	0.	.40611E-10	.52765E-06	.79701E-04
315984.	0.	.13577E-09	.41843E-09	0.	.40480E-10	.51936E-06	.78548E-04
317750.	0.	.12078E-09	.41709E-09	0.	.40349E-10	.51121E-06	.77413E-04
319515.	0.	.10858E-09	.41574E-09	0.	.40219E-10	.50320E-06	.76295E-04

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321280.	0.	.98659E-10	.41440E-09	0.	.40090E-10	.49533E-06	.75193E-04
323045.	0.	.90594E-10	.41307E-09	0.	.39960E-10	.48758E-06	.74108E-04
324811.	0.	.84045E-10	.41173E-09	0.	.39832E-10	.47996E-06	.73039E-04
326576.	0.	.78728E-10	.41041E-09	0.	.39703E-10	.47247E-06	.71986E-04
328341.	0.	.74415E-10	.40908E-09	0.	.39575E-10	.46510E-06	.70949E-04
330107.	0.	.70918E-10	.40777E-09	0.	.39448E-10	.45785E-06	.69926E-04
331872.	0.	.68084E-10	.40645E-09	0.	.39321E-10	.45071E-06	.68919E-04
333637.	0.	.65789E-10	.40514E-09	0.	.39194E-10	.44369E-06	.67927E-04
335402.	0.	.63932E-10	.40384E-09	0.	.39067E-10	.43679E-06	.66950E-04
337168.	0.	.62429E-10	.40253E-09	0.	.38942E-10	.42999E-06	.65987E-04
338933.	0.	.61213E-10	.40124E-09	0.	.38816E-10	.42331E-06	.65039E-04
340698.	0.	.60231E-10	.39994E-09	0.	.38691E-10	.41673E-06	.64104E-04
342464.	0.	.59437E-10	.39865E-09	0.	.38566E-10	.41025E-06	.63184E-04
344229.	0.	.58796E-10	.39737E-09	0.	.38442E-10	.40388E-06	.62276E-04
345994.	0.	.58278E-10	.39609E-09	0.	.38318E-10	.39761E-06	.61383E-04
347759.	0.	.57861E-10	.39481E-09	0.	.38194E-10	.39144E-06	.60502E-04
349525.	0.	.57524E-10	.39354E-09	0.	.38071E-10	.38537E-06	.59635E-04
351290.	0.	.57252E-10	.39227E-09	0.	.37949E-10	.37939E-06	.58780E-04
353055.	0.	.57033E-10	.39101E-09	0.	.37826E-10	.37350E-06	.57938E-04
354820.	0.	.56857E-10	.38975E-09	0.	.37704E-10	.36771E-06	.57108E-04
356586.	0.	.56715E-10	.38849E-09	0.	.37583E-10	.36201E-06	.56291E-04
358351.	0.	.56600E-10	.38724E-09	0.	.37462E-10	.35640E-06	.55486E-04
360116.	0.	.56508E-10	.38599E-09	0.	.37341E-10	.35088E-06	.54692E-04
361882.	0.	.56434E-10	.38474E-09	0.	.37221E-10	.34544E-06	.53910E-04
363647.	0.	.56374E-10	.38350E-09	0.	.37101E-10	.34009E-06	.53140E-04
365412.	0.	.56326E-10	.38227E-09	0.	.36981E-10	.33483E-06	.52381E-04
367177.	0.	.56287E-10	.38104E-09	0.	.36862E-10	.32964E-06	.51633E-04
368943.	0.	.56256E-10	.37981E-09	0.	.36743E-10	.32454E-06	.50897E-04
370708.	0.	.56231E-10	.37858E-09	0.	.36625E-10	.31951E-06	.50171E-04
372473.	0.	.56211E-10	.37736E-09	0.	.36507E-10	.31457E-06	.49455E-04
374238.	0.	.56195E-10	.37615E-09	0.	.36389E-10	.30970E-06	.48751E-04
376004.	0.	.56182E-10	.37493E-09	0.	.36272E-10	.30491E-06	.48056E-04
377769.	0.	.56171E-10	.37373E-09	0.	.36155E-10	.30019E-06	.47372E-04
379534.	0.	.56163E-10	.37252E-09	0.	.36038E-10	.29551E-06	.46698E-04
381300.	0.	.56156E-10	.37132E-09	0.	.35922E-10	.29097E-06	.46033E-04
383065.	0.	.56151E-10	.37012E-09	0.	.35806E-10	.28647E-06	.45379E-04
384830.	0.	.56147E-10	.36893E-09	0.	.35691E-10	.28204E-06	.44734E-04
386595.	0.	.56143E-10	.36774E-09	0.	.35576E-10	.27768E-06	.44098E-04
388361.	0.	.56140E-10	.36656E-09	0.	.35461E-10	.27338E-06	.43472E-04
390126.	0.	.56138E-10	.36537E-09	0.	.35347E-10	.26916E-06	.42855E-04
391891.	0.	.56136E-10	.36420E-09	0.	.35233E-10	.26499E-06	.42247E-04
393657.	0.	.56135E-10	.36302E-09	0.	.35119E-10	.26090E-06	.41648E-04
395422.	0.	.56134E-10	.36185E-09	0.	.35006E-10	.25686E-06	.41057E-04
397187.	0.	.56133E-10	.36069E-09	0.	.34893E-10	.25289E-06	.40476E-04
398952.	0.	.56132E-10	.35952E-09	0.	.34781E-10	.24898E-06	.39902E-04
400718.	0.	.56131E-10	.35836E-09	0.	.34669E-10	.24513E-06	.39337E-04
402483.	0.	.56131E-10	.35721E-09	0.	.34557E-10	.24134E-06	.38781E-04
404248.	0.	.56[illegible]0E-10	.35606E-09	0.	.34445E-10	.23761E-06	.38232E-04
406013.	0.	.5[illegible]E-10	.35491E-09	0.	.34334E-10	.23394E-06	.37692E-04
407779.	0.	[illegible]E-10	.35377E-09	0.	.34224E-10	.23032E-06	.37159E-04
409544.	0.	[illegible]E-10	.35263E-09	0.	.34113E-10	.22676E-06	.36634E-04
411309.	0.	[illegible]9E-10	.35149E-09	0.	.34004E-10	.22326E-06	.36117E-04
413075.	0.	.[illegible]29E-10	.35036E-09	0.	.33894E-10	.21981E-06	.35608E-04
414840.	0.	.56129E-10	.34923E-09	0.	.33785E-10	.21641E-06	.35105E-04
416605.	0.	.56129E-10	.34810E-09	0.	.33676E-10	.21307E-06	.34611E-04
418370.	0.	.56129E-10	.34698E-09	0.	.33567E-10	.20977E-06	.34123E-04
420136.	0.	.56129E-10	.34586E-09	0.	.33459E-10	.20653E-06	.33642E-04
421901.	0.	.56129E-10	.34475E-09	0.	.33351E-10	.20334E-06	.33169E-04
423666.	0.	.56129E-10	.34364E-09	0.	.33244E-10	.20020E-06	.32702E-04
425431.	0.	.56129E-10	.34253E-09	0.	.33137E-10	.19710E-06	.32242E-04

YEAR	CM246	PU242	U238	PU238	U234	TH230	RA226
427197.	0.	.56129E-10	.34142E-09	0.	.33030E-10	.19406E-06	.31789E-04
428962.	0.	.56129E-10	.34032E-09	0.	.32923E-10	.19106E-06	.31342E-04
430727.	0.	.56129E-10	.33923E-09	0.	.32817E-10	.18811E-06	.30902E-04
432493.	0.	.56129E-10	.33813E-09	0.	.32711E-10	.18520E-06	.30468E-04
434258.	0.	.56129E-10	.33704E-09	0.	.32606E-10	.18234E-06	.30041E-04
436023.	0.	.56129E-10	.33596E-09	0.	.32501E-10	.17952E-06	.29620E-04
437788.	0.	.56129E-10	.33487E-09	0.	.32396E-10	.17675E-06	.29204E-04
439554.	0.	.56129E-10	.33379E-09	0.	.32292E-10	.17402E-06	.28795E-04
441319.	0.	.56129E-10	.33272E-09	0.	.32188E-10	.17133E-06	.28392E-04
443084.	0.	.56129E-10	.33165E-09	0.	.32084E-10	.16868E-06	.27995E-04
444849.	0.	.56129E-10	.33058E-09	0.	.31980E-10	.16608E-06	.27603E-04
446615.	0.	.56129E-10	.32951E-09	0.	.31877E-10	.16351E-06	.27217E-04
448380.	0.	.56129E-10	.32845E-09	0.	.31775E-10	.16098E-06	.26837E-04
450145.	0.	.56129E-10	.32739E-09	0.	.31672E-10	.15850E-06	.26462E-04
451911.	0.	.56129E-10	.32633E-09	0.	.31570E-10	.15605E-06	.26092E-04
453676.	0.	.56129E-10	.32528E-09	0.	.31468E-10	.15364E-06	.25728E-04
455441.	0.	.56129E-10	.32423E-09	0.	.31367E-10	.15126E-06	.25370E-04
457206.	0.	.56129E-10	.32319E-09	0.	.31266E-10	.14893E-06	.25016E-04
458972.	0.	.56129E-10	.32215E-09	0.	.31165E-10	.14663E-06	.24667E-04
460737.	0.	.56129E-10	.32111E-09	0.	.31064E-10	.14436E-06	.24324E-04
462502.	0.	.56129E-10	.32007E-09	0.	.30964E-10	.14213E-06	.23985E-04
464268.	0.	.56129E-10	.31904E-09	0.	.30865E-10	.13994E-06	.23652E-04
466033.	0.	.56129E-10	.31801E-09	0.	.30765E-10	.13777E-06	.23323E-04
467798.	0.	.56129E-10	.31699E-09	0.	.30666E-10	.13565E-06	.22999E-04
469563.	0.	.56129E-10	.31597E-09	0.	.30567E-10	.13355E-06	.22679E-04
471329.	0.	.56129E-10	.31495E-09	0.	.30469E-10	.13149E-06	.22364E-04
473094.	0.	.56129E-10	.31393E-09	0.	.30370E-10	.12946E-06	.22054E-04
474859.	0.	.56129E-10	.31292E-09	0.	.30272E-10	.12746E-06	.21748E-04
476624.	0.	.56129E-10	.31191E-09	0.	.30175E-10	.12549E-06	.21447E-04
478390.	0.	.56129E-10	.31091E-09	0.	.30078E-10	.12355E-06	.21150E-04
480155.	0.	.56129E-10	.30991E-09	0.	.29981E-10	.12164E-06	.20857E-04
481920.	0.	.56129E-10	.30891E-09	0.	.29884E-10	.11976E-06	.20568E-04
483686.	0.	.56129E-10	.30791E-09	0.	.29788E-10	.11791E-06	.20284E-04
485451.	0.	.56129E-10	.30692E-09	0.	.29692E-10	.11609E-06	.20003E-04
487216.	0.	.56129E-10	.30593E-09	0.	.29596E-10	.11430E-06	.19727E-04
488981.	0.	.56129E-10	.30494E-09	0.	.29501E-10	.11253E-06	.19454E-04
490747.	0.	.56129E-10	.30396E-09	0.	.29405E-10	.11079E-06	.19186E-04
492512.	0.	.56129E-10	.30298E-09	0.	.29311E-10	.10908E-06	.18921E-04
494277.	0.	.56129E-10	.30200E-09	0.	.29216E-10	.10740E-06	.18660E-04
496042.	0.	.56129E-10	.30103E-09	0.	.29122E-10	.10574E-06	.18403E-04
497808.	0.	.56129E-10	.30006E-09	0.	.29028E-10	.10410E-06	.18150E-04
499573.	0.	.56129E-10	.29909E-09	0.	.28935E-10	.10250E-06	.17900E-04
501338.	0.	.56129E-10	.29813E-09	0.	.28841E-10	.10091E-06	.17654E-04
503104.	0.	.56129E-10	.29717E-09	0.	.28748E-10	.99353E-07	.17411E-04
504869.	0.	.56129E-10	.29621E-09	0.	.28656E-10	.97818E-07	.17172E-04
506634.	0.	.56129E-10	.29525E-09	0.	.28563E-10	.96307E-07	.16936E-04
508399.	0.	.56129E-10	.29430E-09	0.	.28471E-10	.94820E-07	.16703E-04
510165.	0.	.56129E-10	.29335E-09	0.	.28379E-10	.93355E-07	.16474E-04
511930.	0.	.56129E-10	.29241E-09	0.	.28288E-10	.91913E-07	.16248E-04
513695.	0.	.56129E-10	.29147E-09	0.	.28197E-10	.90493E-07	.16026E-04
515461.	0.	.56129E-10	.29053E-09	0.	.28106E-10	.89095E-07	.15806E-04
517226.	0.	.56129E-10	.28959E-09	0.	.28015E-10	.87719E-07	.15590E-04
518991.	0.	.56129E-10	.28866E-09	0.	.27925E-10	.86364E-07	.15377E-04
520756.	0.	.56129E-10	.28773E-09	0.	.27835E-10	.85030E-07	.15166E-04
522522.	0.	.56129E-10	.28680E-09	0.	.27745E-10	.83717E-07	.14959E-04
524287.	0.	.56129E-10	.28587E-09	0.	.27656E-10	.82423E-07	.14755E-04
526052.	0.	.56129E-10	.28495E-09	0.	.27567E-10	.81150E-07	.14553E-04
527817.	0.	.56129E-10	.28403E-09	0.	.27478E-10	.79897E-07	.14355E-04
529583.	0.	.56129E-10	.28312E-09	0.	.27389E-10	.78663E-07	.14159E-04
531348.	0.	.56129E-10	.28221E-09	0.	.27301E-10	.77448E-07	.13966E-04

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533113.	0.	.56129E-10	.28130E-09	0.	.27213E-10	.76251E-07	.13776E-04
534879.	0.	.56129E-10	.28039E-09	0.	.27125E-10	.75073E-07	.13588E-04
536644.	0.	.56129E-10	.27949E-09	0.	.27038E-10	.73914E-07	.13404E-04
538409.	0.	.56129E-10	.27859E-09	0.	.26951E-10	.72772E-07	.13221E-04
540174.	0.	.56129E-10	.27769E-09	0.	.26864E-10	.71648E-07	.13042E-04
541940.	0.	.56129E-10	.27679E-09	0.	.26777E-10	.70541E-07	.12865E-04
543705.	0.	.56129E-10	.27590E-09	0.	.26691E-10	.69452E-07	.12690E-04
545470.	0.	.56129E-10	.27501E-09	0.	.26605E-10	.68379E-07	.12518E-04
547235.	0.	.56129E-10	.27412E-09	0.	.26519E-10	.67323E-07	.12348E-04
549001.	0.	.56129E-10	.27324E-09	0.	.26434E-10	.66283E-07	.12181E-04
550766.	0.	.56129E-10	.27236E-09	0.	.26348E-10	.65259E-07	.12016E-04
552531.	0.	.56129E-10	.27148E-09	0.	.26264E-10	.64251E-07	.11854E-04
554297.	0.	.56129E-10	.27061E-09	0.	.26179E-10	.63258E-07	.11693E-04
556062.	0.	.56129E-10	.26974E-09	0.	.26094E-10	.62281E-07	.11535E-04
557827.	0.	.56129E-10	.26887E-09	0.	.26010E-10	.61319E-07	.11379E-04
559592.	0.	.56129E-10	.26800E-09	0.	.25927E-10	.60372E-07	.11226E-04
561358.	0.	.56129E-10	.26714E-09	0.	.25843E-10	.59440E-07	.11074E-04
563123.	0.	.56129E-10	.26627E-09	0.	.25760E-10	.58521E-07	.10925E-04
564888.	0.	.56129E-10	.26542E-09	0.	.25677E-10	.57618E-07	.10778E-04
566654.	0.	.56129E-10	.26456E-09	0.	.25594E-10	.56728E-07	.10633E-04
568419.	0.	.56129E-10	.26371E-09	0.	.25511E-10	.55851E-07	.10490E-04
570184.	0.	.56129E-10	.26286E-09	0.	.25429E-10	.54989E-07	.10349E-04
571949.	0.	.56129E-10	.26201E-09	0.	.25347E-10	.54139E-07	.10210E-04
573715.	0.	.56129E-10	.26117E-09	0.	.25265E-10	.53303E-07	.10072E-04
575480.	0.	.56129E-10	.26032E-09	0.	.25184E-10	.52480E-07	.99372E-05
577245.	0.	.56129E-10	.25948E-09	0.	.25103E-10	.51669E-07	.98039E-05
579010.	0.	.56129E-10	.25865E-09	0.	.25022E-10	.50871E-07	.96724E-05
580776.	0.	.56129E-10	.25781E-09	0.	.24941E-10	.50085E-07	.95428E-05
582541.	0.	.56129E-10	.25698E-09	0.	.24861E-10	.49311E-07	.94151E-05
584306.	0.	.56129E-10	.25616E-09	0.	.24781E-10	.48550E-07	.92891E-05
586072.	0.	.56129E-10	.25533E-09	0.	.24701E-10	.47800E-07	.91648E-05
587837.	0.	.56129E-10	.25451E-09	0.	.24621E-10	.47062E-07	.90423E-05
589602.	0.	.56129E-10	.25369E-09	0.	.24542E-10	.46335E-07	.89216E-05
591367.	0.	.56129E-10	.25287E-09	0.	.24463E-10	.45619E-07	.88025E-05
593133.	0.	.56129E-10	.25205E-09	0.	.24384E-10	.44914E-07	.86851E-05
594898.	0.	.56129E-10	.25124E-09	0.	.24305E-10	.44221E-07	.85693E-05
596663.	0.	.56129E-10	.25043E-09	0.	.24227E-10	.43537E-07	.84551E-05
598428.	0.	.56129E-10	.24962E-09	0.	.24149E-10	.42865E-07	.83425E-05
600194.	0.	.56129E-10	.24882E-09	0.	.24071E-10	.42203E-07	.82315E-05
601959.	0.	.56129E-10	.24802E-09	0.	.23993E-10	.41551E-07	.81221E-05
603724.	0.	.56129E-10	.24722E-09	0.	.23916E-10	.40909E-07	.80141E-05
605490.	0.	.56129E-10	.24642E-09	0.	.23839E-10	.40277E-07	.79077E-05
607255.	0.	.56129E-10	.24563E-09	0.	.23762E-10	.39655E-07	.78027E-05
609020.	0.	.56129E-10	.24483E-09	0.	.23686E-10	.39043E-07	.76993E-05
610785.	0.	.56129E-10	.24405E-09	0.	.23609E-10	.38440E-07	.75972E-05
612551.	0.	.56129E-10	.24326E-09	0.	.23533E-10	.37846E-07	.74966E-05
614316.	0.	.56129E-10	.24247E-09	0.	.23457E-10	.37261E-07	.73973E-05
616081.	0.	.56129E-10	.24169E-09	0.	.23382E-10	.36686E-07	.72995E-05
617847.	0.	.56129E-10	.24091E-09	0.	.23306E-10	.36119E-07	.72030E-05
619612.	0.	.56129E-10	.24014E-09	0.	.23231E-10	.35561E-07	.71078E-05
621377.	0.	.56129E-10	.23936E-09	0.	.23156E-10	.35012E-07	.70140E-05
623142.	0.	.56129E-10	.23859E-09	0.	.23082E-10	.34471E-07	.69215E-05
624908.	0.	.56129E-10	.23782E-09	0.	.23007E-10	.33939E-07	.68302E-05
626673.	0.	.56129E-10	.23706E-09	0.	.22933E-10	.33414E-07	.67402E-05
628438.	0.	.56129E-10	.23629E-09	0.	.22859E-10	.32898E-07	.66514E-05
630203.	0.	.56129E-10	.23553E-09	0.	.22785E-10	.32390E-07	.65639E-05
631969.	0.	.56129E-10	.23477E-09	0.	.22712E-10	.31890E-07	.64776E-05
633734.	0.	.56129E-10	.23401E-09	0.	.22639E-10	.31397E-07	.63925E-05
635499.	0.	.56129E-10	.23326E-09	0.	.22566E-10	.30912E-07	.63085E-05
637265.	0.	.56129E-10	.23251E-09	0.	.22493E-10	.30435E-07	.62258E-05

YEAR	CM246	PU242	U238	PU238	U234	TH230	RA226
639030.	0.	.56129E-10	.23176E-09	0.	.22421E-10	.29965E-07	.61441E-05
640795.	0.	.56129E-10	.23101E-09	0.	.22348E-10	.29502E-07	.60636E-05
642560.	0.	.56129E-10	.23027E-09	0.	.22276E-10	.29046E-07	.59842E-05
644326.	0.	.56129E-10	.22953E-09	0.	.22205E-10	.28597E-07	.59059E-05
646091.	0.	.56129E-10	.22879E-09	0.	.22133E-10	.28156E-07	.58286E-05
647856.	0.	.56129E-10	.22805E-09	0.	.22062E-10	.27721E-07	.57524E-05
649621.	0.	.56129E-10	.22731E-09	0.	.21990E-10	.27293E-07	.56773E-05
651387.	0.	.56129E-10	.22658E-09	0.	.21920E-10	.26871E-07	.56032E-05
653152.	0.	.56129E-10	.22585E-09	0.	.21849E-10	.26456E-07	.55301E-05
654917.	0.	.56129E-10	.22512E-09	0.	.21779E-10	.26047E-07	.54580E-05
656683.	0.	.56129E-10	.22440E-09	0.	.21708E-10	.25645E-07	.53869E-05
658448.	0.	.56129E-10	.22367E-09	0.	.21638E-10	.25249E-07	.53168E-05
660213.	0.	.56129E-10	.22295E-09	0.	.21569E-10	.24859E-07	.52477E-05
661978.	0.	.56129E-10	.22223E-09	0.	.21499E-10	.24475E-07	.51795E-05
663744.	0.	.56129E-10	.22152E-09	0.	.21430E-10	.24097E-07	.51122E-05
665509.	0.	.56129E-10	.22080E-09	0.	.21361E-10	.23725E-07	.50458E-05
667274.	0.	.56129E-10	.22009E-09	0.	.21292E-10	.23358E-07	.49804E-05
669040.	0.	.56129E-10	.21938E-09	0.	.21223E-10	.22997E-07	.49158E-05
670805.	0.	.56129E-10	.21867E-09	0.	.21155E-10	.22642E-07	.48521E-05
672570.	0.	.56129E-10	.21797E-09	0.	.21087E-10	.22293E-07	.47893E-05
674335.	0.	.56129E-10	.21727E-09	0.	.21019E-10	.21948E-07	.47274E-05
676101.	0.	.56129E-10	.21657E-09	0.	.20951E-10	.21609E-07	.46663E-05
677866.	0.	.56129E-10	.21587E-09	0.	.20883E-10	.21275E-07	.46060E-05
679631.	0.	.56129E-10	.21517E-09	0.	.20816E-10	.20947E-07	.45466E-05
681396.	0.	.56129E-10	.21448E-09	0.	.20749E-10	.20623E-07	.44879E-05
683162.	0.	.56129E-10	.21379E-09	0.	.20682E-10	.20305E-07	.44301E-05
684927.	0.	.56129E-10	.21310E-09	0.	.20615E-10	.19991E-07	.43730E-05
686692.	0.	.56129E-10	.21241E-09	0.	.20549E-10	.19682E-07	.43167E-05
688458.	0.	.56129E-10	.21173E-09	0.	.20483E-10	.19378E-07	.42612E-05
690223.	0.	.56129E-10	.21104E-09	0.	.20417E-10	.19079E-07	.42064E-05
691988.	0.	.56129E-10	.21036E-09	0.	.20351E-10	.18784E-07	.41524E-05
693753.	0.	.56129E-10	.20969E-09	0.	.20285E-10	.18494E-07	.40991E-05
695519.	0.	.56129E-10	.20901E-09	0.	.20220E-10	.18208E-07	.40465E-05
697284.	0.	.56129E-10	.20834E-09	0.	.20155E-10	.17927E-07	.39947E-05
699049.	0.	.56129E-10	.20767E-09	0.	.20090E-10	.17650E-07	.39435E-05
700814.	0.	.56129E-10	.20700E-09	0.	.20025E-10	.17378E-07	.38931E-05
702580.	0.	.56129E-10	.20633E-09	0.	.19960E-10	.17109E-07	.38433E-05
704345.	0.	.56129E-10	.20566E-09	0.	.19896E-10	.16845E-07	.37942E-05
706110.	0.	.56129E-10	.20500E-09	0.	.19832E-10	.16585E-07	.37457E-05
707876.	0.	.56129E-10	.20434E-09	0.	.19768E-10	.16329E-07	.36979E-05
709641.	0.	.56129E-10	.20368E-09	0.	.19704E-10	.16076E-07	.36508E-05
711406.	0.	.56129E-10	.20302E-09	0.	.19641E-10	.15828E-07	.36042E-05
713171.	0.	.56129E-10	.20237E-09	0.	.19578E-10	.15584E-07	.35584E-05
714937.	0.	.56129E-10	.20172E-09	0.	.19514E-10	.15343E-07	.35131E-05
716702.	0.	.56129E-10	.20107E-09	0.	.19451E-10	.15106E-07	.34684E-05
718467.	0.	.56129E-10	.20042E-09	0.	.19389E-10	.14873E-07	.34244E-05
720233.	0.	.56129E-10	.19977E-09	0.	.19326E-10	.14643E-07	.33809E-05
721998.	0.	.56129E-10	.19913E-09	0.	.19264E-10	.14417E-07	.33380E-05
723763.	0.	.56129E-10	.19849E-09	0.	.19202E-10	.14194E-07	.32957E-05
725520.	0.	.56129E-10	.19785E-09	0.	.19140E-10	.13975E-07	.32539E-05
727294.	0.	.56129E-10	.19721E-09	0.	.19078E-10	.13759E-07	.32127E-05
729059.	0.	.56129E-10	.19657E-09	0.	.19017E-10	.13546E-07	.31721E-05
730824.	0.	.56129E-10	.19594E-09	0.	.18956E-10	.13337E-07	.31320E-05
732589.	0.	.56129E-10	.19531E-09	0.	.18894E-10	.13131E-07	.30925E-05
734355.	0.	.56129E-10	.19468E-09	0.	.18834E-10	.12928E-07	.30534E-05
736120.	0.	.56129E-10	.19405E-09	0.	.18773E-10	.12729E-07	.30149E-05
737885.	0.	.56129E-10	.19343E-09	0.	.18712E-10	.12532E-07	.29769E-05
739651.	0.	.56129E-10	.19280E-09	0.	.18652E-10	.12339E-07	.29394E-05
741416.	0.	.56129E-10	.19218E-09	0.	.18592E-10	.12148E-07	.29024E-05
743181.	0.	.56129E-10	.19156E-09	0.	.18532E-10	.11960E-07	.28660E-05

YEAR	CM246	PU242	U238	PU238	U234	TH230	RA226
744946.	0.	.56129E-10	.19094E-09	0.	.18472E-10	.11776E-07	.28299E-05
746712.	0.	.56129E-10	.19033E-09	0.	.18413E-10	.11594E-07	.27944E-05
748477.	0.	.56129E-10	.18972E-09	0.	.18353E-10	.11415E-07	.27594E-05
750242.	0.	.56129E-10	.18910E-09	0.	.18294E-10	.11238E-07	.27248E-05
752007.	0.	.56129E-10	.18849E-09	0.	.18235E-10	.11065E-07	.26906E-05
753773.	0.	.56129E-10	.18789E-09	0.	.18176E-10	.10894E-07	.26570E-05
755538.	0.	.56129E-10	.18728E-09	0.	.18118E-10	.10726E-07	.26237E-05
757303.	0.	.56129E-10	.18668E-09	0.	.18059E-10	.10560E-07	.25909E-05
759069.	0.	.56129E-10	.18608E-09	0.	.18001E-10	.10397E-07	.25586E-05
760834.	0.	.56129E-10	.18548E-09	0.	.17943E-10	.10236E-07	.25266E-05
762599.	0.	.56129E-10	.18488E-09	0.	.17885E-10	.10078E-07	.24951E-05
764364.	0.	.56129E-10	.18428E-09	0.	.17828E-10	.99225E-08	.24641E-05
766130.	0.	.56129E-10	.18369E-09	0.	.17770E-10	.97692E-08	.24334E-05
767895.	0.	.56129E-10	.18310E-09	0.	.17713E-10	.96183E-08	.24031E-05
769660.	0.	.56129E-10	.18251E-09	0.	.17656E-10	.94698E-08	.23732E-05
771426.	0.	.56129E-10	.18192E-09	0.	.17599E-10	.93235E-08	.23437E-05
773191.	0.	.56129E-10	.18133E-09	0.	.17542E-10	.91795E-08	.23147E-05
774956.	0.	.56129E-10	.18075E-09	0.	.17486E-10	.90378E-08	.22859E-05
776721.	0.	.56129E-10	.18016E-09	0.	.17429E-10	.88982E-08	.22576E-05
778487.	0.	.56129E-10	.17958E-09	0.	.17373E-10	.87608E-08	.22297E-05
780252.	0.	.56129E-10	.17900E-09	0.	.17317E-10	.86254E-08	.22021E-05
782017.	0.	.56129E-10	.17843E-09	0.	.17261E-10	.84922E-08	.21748E-05
783782.	0.	.56129E-10	.17785E-09	0.	.17206E-10	.83611E-08	.21480E-05
785548.	0.	.56129E-10	.17728E-09	0.	.17150E-10	.82320E-08	.21215E-05
787313.	0.	.56129E-10	.17671E-09	0.	.17095E-10	.81048E-08	.20953E-05
789078.	0.	.56129E-10	.17614E-09	0.	.17040E-10	.79797E-08	.20695E-05
790844.	0.	.56129E-10	.17557E-09	0.	.16985E-10	.78564E-08	.20440E-05
792609.	0.	.56129E-10	.17500E-09	0.	.16930E-10	.77351E-08	.20188E-05
794374.	0.	.56129E-10	.17444E-09	0.	.16876E-10	.76157E-08	.19940E-05
796139.	0.	.56129E-10	.17388E-09	0.	.16821E-10	.74981E-08	.19695E-05
797905.	0.	.56129E-10	.17332E-09	0.	.16767E-10	.73823E-08	.19453E-05
799670.	0.	.56129E-10	.17276E-09	0.	.16713E-10	.72683E-08	.19214E-05
801435.	0.	.56129E-10	.17220E-09	0.	.16659E-10	.71560E-08	.18979E-05
803200.	0.	.56129E-10	.17165E-09	0.	.16605E-10	.70456E-08	.18746E-05
804966.	0.	.56129E-10	.17109E-09	0.	.16552E-10	.69368E-08	.18517E-05
806731.	0.	.56129E-10	.17054E-09	0.	.16498E-10	.68297E-08	.18290E-05
808496.	0.	.56129E-10	.16999E-09	0.	.16445E-10	.67242E-08	.18067E-05
810262.	0.	.56129E-10	.16944E-09	0.	.16392E-10	.66204E-08	.17846E-05
812027.	0.	.56129E-10	.16890E-09	0.	.16339E-10	.65182E-08	.17629E-05
813792.	0.	.56129E-10	.16835E-09	0.	.16287E-10	.64176E-08	.17414E-05
815557.	0.	.56129E-10	.16781E-09	0.	.16234E-10	.63185E-08	.17202E-05
817323.	0.	.56129E-10	.16727E-09	0.	.16182E-10	.62209E-08	.16992E-05
819088.	0.	.56129E-10	.16673E-09	0.	.16130E-10	.61249E-08	.16786E-05
820853.	0.	.56129E-10	.16619E-09	0.	.16078E-10	.60304E-08	.16582E-05
822619.	0.	.56129E-10	.16566E-09	0.	.16026E-10	.59373E-08	.16380E-05
824384.	0.	.56129E-10	.16512E-09	0.	.15974E-10	.58457E-08	.16182E-05
826149.	0.	.56129E-10	.16459E-09	0.	.15923E-10	.57554E-08	.15985E-05
827914.	0.	.56129E-10	.16406E-09	0.	.15871E-10	.56666E-08	.15792E-05
829680.	0.	.56129E-10	.16353E-09	0.	.15820E-10	.55792E-08	.15601E-05
831445.	0.	.56129E-10	.16301E-09	0.	.15769E-10	.54931E-08	.15412E-05
833212.	0.	.56129E-10	.16248E-09	0.	.15718E-10	.54083E-08	.15226E-05
834975.	0.	.56129E-10	.16196E-09	0.	.15668E-10	.53249E-08	.15042E-05
836741.	0.	.56129E-10	.16143E-09	0.	.15617E-10	.52427E-08	.14861E-05
838506.	0.	.56129E-10	.16091E-09	0.	.15567E-10	.51619E-08	.14682E-05
840271.	0.	.56129E-10	.16040E-09	0.	.15517E-10	.50822E-08	.14505E-05
842037.	0.	.56129E-10	.15988E-09	0.	.15467E-10	.50039E-08	.14330E-05
843802.	0.	.56129E-10	.15936E-09	0.	.15417E-10	.49267E-08	.14158E-05
845567.	0.	.56129E-10	.15885E-09	0.	.15367E-10	.48507E-08	.13988E-05
847332.	0.	.56129E-10	.15834E-09	0.	.15318E-10	.47759E-08	.13820E-05
849098.	0.	.56129E-10	.15783E-09	0.	.15268E-10	.47023E-08	.13654E-05

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850863.	0.	.56129E-10	.15732E-09	0.	.15219E-10	.46298E-08	.13491E-05
852628.	0.	.56129E-10	.15681E-09	0.	.15170E-10	.45585E-08	.13329E-05
854393.	0.	.56129E-10	.15631E-09	0.	.15121E-10	.44882E-08	.13170E-05
856159.	0.	.56129E-10	.15580E-09	0.	.15072E-10	.44191E-08	.13012E-05
857924.	0.	.56129E-10	.15530E-09	0.	.15024E-10	.43510E-08	.12857E-05
859689.	0.	.56129E-10	.15480E-09	0.	.14975E-10	.42840E-08	.12703E-05
861455.	0.	.56129E-10	.15430E-09	0.	.14927E-10	.42180E-08	.12552E-05
863220.	0.	.56129E-10	.15380E-09	0.	.14879E-10	.41530E-08	.12402E-05
864985.	0.	.56129E-10	.15331E-09	0.	.14831E-10	.40891E-08	.12255E-05
866750.	0.	.56129E-10	.15281E-09	0.	.14783E-10	.40262E-08	.12109E-05
868516.	0.	.56129E-10	.15232E-09	0.	.14736E-10	.39642E-08	.11965E-05
870281.	0.	.56129E-10	.15183E-09	0.	.14688E-10	.39032E-08	.11823E-05
872046.	0.	.56129E-10	.15134E-09	0.	.14641E-10	.38432E-08	.11683E-05
873812.	0.	.56129E-10	.15085E-09	0.	.14594E-10	.37841E-08	.11544E-05
875577.	0.	.56129E-10	.15037E-09	0.	.14547E-10	.37259E-08	.11408E-05
877342.	0.	.56129E-10	.14988E-09	0.	.14500E-10	.36687E-08	.11273E-05
879107.	0.	.56129E-10	.14940E-09	0.	.14453E-10	.36123E-08	.11139E-05
880873.	0.	.56129E-10	.14892E-09	0.	.14406E-10	.35569E-08	.11008E-05
882638.	0.	.56129E-10	.14844E-09	0.	.14360E-10	.35022E-08	.10878E-05
884403.	0.	.56129E-10	.14796E-09	0.	.14314E-10	.34485E-08	.10749E-05
886168.	0.	.56129E-10	.14748E-09	0.	.14267E-10	.33956E-08	.10623E-05
887934.	0.	.56129E-10	.14701E-09	0.	.14221E-10	.33435E-08	.10498E-05
889699.	0.	.56129E-10	.14653E-09	0.	.14176E-10	.32923E-08	.10374E-05
891464.	0.	.56129E-10	.14606E-09	0.	.14130E-10	.32418E-08	.10252E-05
893230.	0.	.56129E-10	.14559E-09	0.	.14084E-10	.31922E-08	.10132E-05
894995.	0.	.56129E-10	.14512E-09	0.	.14039E-10	.31433E-08	.10013E-05
896760.	0.	.56129E-10	.14465E-09	0.	.13994E-10	.30952E-08	.98957E-06
898525.	0.	.56129E-10	.14419E-09	0.	.13949E-10	.30479E-08	.97798E-06
900291.	0.	.56129E-10	.14372E-09	0.	.13904E-10	.30013E-08	.96653E-06
902056.	0.	.56129E-10	.14326E-09	0.	.13859E-10	.29555E-08	.95523E-06
903821.	0.	.56129E-10	.14280E-09	0.	.13814E-10	.29104E-08	.94407E-06
905586.	0.	.56129E-10	.14234E-09	0.	.13770E-10	.28660E-08	.93305E-06
907352.	0.	.56129E-10	.14188E-09	0.	.13725E-10	.28223E-08	.92216E-06
909117.	0.	.56129E-10	.14142E-09	0.	.13681E-10	.27793E-08	.91142E-06
910882.	0.	.56129E-10	.14096E-09	0.	.13637E-10	.27370E-08	.90080E-06
912648.	0.	.56129E-10	.14051E-09	0.	.13593E-10	.26953E-08	.89032E-06
914413.	0.	.56129E-10	.14006E-09	0.	.13549E-10	.26544E-08	.87997E-06
916178.	0.	.56129E-10	.13960E-09	0.	.13505E-10	.26141E-08	.86975E-06
917943.	0.	.56129E-10	.13915E-09	0.	.13462E-10	.25744E-08	.85966E-06
919709.	0.	.56129E-10	.13871E-09	0.	.13419E-10	.25354E-08	.84969E-06
921474.	0.	.56129E-10	.13826E-09	0.	.13375E-10	.24970E-08	.83984E-06
923239.	0.	.56129E-10	.13781E-09	0.	.13332E-10	.24592E-08	.83012E-06
925005.	0.	.56129E-10	.13737E-09	0.	.13289E-10	.24220E-08	.82052E-06
926770.	0.	.56129E-10	.13693E-09	0.	.13246E-10	.23855E-08	.81104E-06
928535.	0.	.56129E-10	.13648E-09	0.	.13204E-10	.23495E-08	.80167E-06
930300.	0.	.56129E-10	.13604E-09	0.	.13161E-10	.23141E-08	.79242E-06
932066.	0.	.56129E-10	.13561E-09	0.	.13119E-10	.22793E-08	.78328E-06
933831.	0.	.56129E-10	.13517E-09	0.	.13076E-10	.22451E-08	.77426E-06
935596.	0.	.56129E-10	.13473E-09	0.	.13034E-10	.22114E-08	.76535E-06
937361.	0.	.56129E-10	.13430E-09	0.	.12992E-10	.21783E-08	.75654E-06
939127.	0.	.56129E-10	.13387E-09	0.	.12950E-10	.21457E-08	.74785E-06
940892.	0.	.56129E-10	.13343E-09	0.	.12909E-10	.21137E-08	.73926E-06
942657.	0.	.56129E-10	.13300E-09	0.	.12867E-10	.20821E-08	.73078E-06
944423.	0.	.56129E-10	.13258E-09	0.	.12825E-10	.20511E-08	.72240E-06
946188.	0.	.56129E-10	.13215E-09	0.	.12784E-10	.20207E-08	.71412E-06
947953.	0.	.56129E-10	.13172E-09	0.	.12743E-10	.19907E-08	.70594E-06
949718.	0.	.56129E-10	.13130E-09	0.	.12702E-10	.19612E-08	.69787E-06
951484.	0.	.56129E-10	.13087E-09	0.	.12661E-10	.19322E-08	.68989E-06
953249.	0.	.56129E-10	.13045E-09	0.	.12620E-10	.19037E-08	.68201E-06
955014.	0.	.56129E-10	.13003E-09	0.	.12579E-10	.18757E-08	.67422E-06

YEAR	CM246	PU242	U238	PU238	U234	TH230	RA226
956779.	0.	.56129E-10	.12961E-09	0.	.12539E-10	.18482E-08	.66653E-06
958545.	0.	.56129E-10	.12920E-09	0.	.12498E-10	.18211E-08	.65893E-06
960310.	0.	.56129E-10	.12878E-09	0.	.12458E-10	.17945E-08	.65143E-06
962075.	0.	.56129E-10	.12836E-09	0.	.12418E-10	.17683E-08	.64401E-06
963841.	0.	.56129E-10	.12795E-09	0.	.12378E-10	.17426E-08	.63669E-06
965606.	0.	.56129E-10	.12754E-09	0.	.12338E-10	.17174E-08	.62945E-06
967371.	0.	.56129E-10	.12713E-09	0.	.12298E-10	.16925E-08	.62230E-06
969136.	0.	.56129E-10	.12672E-09	0.	.12259E-10	.16681E-08	.61524E-06
970902.	0.	.56129E-10	.12631E-09	0.	.12219E-10	.16441E-08	.60826E-06
972667.	0.	.56129E-10	.12590E-09	0.	.12180E-10	.16205E-08	.60136E-06
974432.	0.	.56129E-10	.12550E-09	0.	.12141E-10	.15974E-08	.59455E-06
976198.	0.	.56129E-10	.12509E-09	0.	.12101E-10	.15746E-08	.58782E-06
977963.	0.	.56129E-10	.12469E-09	0.	.12062E-10	.15523E-08	.58117E-06
979728.	0.	.56129E-10	.12429E-09	0.	.12023E-10	.15303E-08	.57459E-06
981493.	0.	.56129E-10	.12389E-09	0.	.11985E-10	.15087E-08	.55810E-06
983259.	0.	.56129E-10	.12349E-09	0.	.11946E-10	.14875E-08	.56168E-06
985024.	0.	.56129E-10	.12309E-09	0.	.11908E-10	.14667E-08	.55534E-06
986789.	0.	.56129E-10	.12269E-09	0.	.11869E-10	.14463E-08	.54907E-06
988554.	0.	.56129E-10	.12230E-09	0.	.11831E-10	.14262E-08	.54288E-06
990320.	0.	.56129E-10	.12190E-09	0.	.11793E-10	.14065E-08	.53676E-06
992085.	0.	.56129E-10	.12151E-09	0.	.11755E-10	.13871E-08	.53072E-06
993850.	0.	.56129E-10	.12112E-09	0.	.11717E-10	.13681E-08	.52474E-06
995616.	0.	.56129E-10	.12073E-09	0.	.11679E-10	.13495E-08	.51883E-06
997381.	0.	.56129E-10	.12034E-09	0.	.11641E-10	.13312E-08	.51300E-06
999146.	0.	.56129E-10	.11995E-09	0.	.11604E-10	.13132E-08	.50723E-06
1000911.	0.	.56129E-10	.11956E-09	0.	.11567E-10	.12956E-08	.50153E-06

DVM / STC

New Right Hand Page

Notebook Divider Should Read: S.P. 5 - Time Step Diff, Anal. Solution

Sample Problems 5A, 5B, 5C, and 5D: Time Step Differences, Analytic Solution

Problem 5 has four parts. The purpose of 5A-5C is to demonstrate the effects that different time steps have on DVM output. In each case the space step is 600 ft. In part 5A we allow (as in the previous sample problems) the subroutine DXDT to determine DT. The resulting value is DT = 2500 yrs. In 5B we force a time step of 8000 yrs and in 5C a time step of 50 yrs. This is done by entering the appropriate DT-values on the DVM control card, BC(15). Problem 5D executes the analytic solution on the same transport problem. This is done mainly for comparison purposes.

Problem 5 uses a modification of the borehole scenario of problem 4. Flow through the borehole is assumed to access a single waste cavern rather than the entire depository. The typical room size is 18 ft x 18 ft x 560 ft. Thus, leg 13 is shortened to 600 ft so that source length is comparable to room size. In this instance we move legs 10 and 12 up-dip 7400 ft. As a result, the lengths of legs 2, 3, 6, 7, 10, 12 and 13 and the elevations of junctions 5 and 9 need to be adjusted. These are accomplished with the use of the dip angle.

The cross-sectional area of leg 13 is

$$\begin{aligned} \text{AREA}(13) &= 560 \text{ ft} \times 18 \text{ ft} \\ &= 10080 \text{ ft}^2. \end{aligned}$$

The porosity of leg 13 is assumed to be .3.

For simplicity a one member decay chain is transported. We create an isotope, AA100, that is quite stable over 10^5 yrs, i.e., we assign a half-life of 10^{20} years. It is arbitrarily given an initial inventory of 1000 ci and a KD of .3 ft^3/lb. Leach time is 20000 years and dispersivity is 100 ft.

Problems 5A through 5D are executed in a single NWFT/DVM run using 4 data sets. Data set 1 is for problem 5A and is described in terms of changes to problem 4 (Table 11-SP).

BC(1) A different title.

SAMPLE PROBLEM NO. 5

BC(5) The cross-sectional area of leg 13 is set to 10080 ft^2.

BC(6) Altered leg lengths are

legs 2, 6, 13	length = 600 ft
legs 3, 7	length = 45400 ft
leg 10	length = 592.24 ft
leg 12	length = 507.76 ft

BC(7) Altered junction elevations are

junction 5	elevation = 3407.05 ft
junction 9	elevation = 2307.05 ft

BC(8) Porosity of leg 13 is assigned 0.3.

BC(12) The number of isotopes is 1 so only one description card is required. It contains

atomic mass = 100

isotope name = AA100

component # = 1

number of parents = 0

half-life = 10^{20} yrs

initial inventory = 10^3 ci

BC(13) Distribution coefficients for AA100 are 0 in legs 13 and 12 and .3 ft^3/lb in legs 7, 8, and 15.

BC(14) Leach time is 20000 years and dispersivity is 100 ft.

BC(15) This is to be a leach-limited run with automatic space and time step determination. Thus a blank suffices here. As a result the BC(16) and BC(17) cards are not input.

BC(18) Set TUB = 10^5 years.

Data set 2 is for problem 5B.

Entries 1 and 15 of the INP array are set to 1 so that the option and DVM control cards are reread.

BC(2) Set options 6 and 7 to 1 to suppress duplicated network output.

BC(15) Set DX = 600 ft and DT = 8000 years.

BC(18) Set TUB = 10^5 years.

Data set 3 is for problem 5C.

Entry 15 of the INP array is set to 1 so that the DVM control card is reread.

BC(15) Set DX = 600 ft and DT = 50 years.

BC(18) Set TUB = 10^5 years.

Data set 4 is for problem 5D.

Entry 1 of the INP array is set to 1 so that the options card is reread.

BC(2) Set options 6, 7, and 13 to 1 and the remainder to zero.

BC(18) Set TUB = 10^5 years.

Graphical displays of discharge rate vs time are depicted in Figure 9-SP. Recalling the discussion of problems 3A and 3B an analytic solution using a constant source boundary condition should form a good basis for comparison to the DVM model for 5A-5C. This is true mainly due to the fact that the source length (600 ft) is small compared to the length of the migration path (147308 ft).

Thus problem 5A represents the best numerical (DVM) solution to the transport problem. Problem 5B suffers from inadequate curve resolution. Problem 5C exhibits numerical dispersion.

In terms of computation time if we let T = execution time required by problem 5A then

1/2 T execution time required by 5B and

21T execution time required by 5C.

These estimates are based on a count of the numerical operations required for each problem. Code output is contained in Table 12-SP.

Table 11-SP. Sample Problem 5 Input Data

```
               SAMPLE PROBLEM NO. 5                                             BC   1
    432.70    646.10    432.70                                                  BC   2
      50.0      50.0      50.0      50.0      40.0      40.0      40.0      40.0    BC   3
    1.5E-6       10.   1.67E-6       10.       10.   1.57E-6       2.5              BC   4
      6.E6      6.E6      6.E6      6.E6     1.8E6     1.8E6     1.8E6     1.8E6    BC   4
        1.       1.0        1.       1.0    10080.        1.     1.2E8              BC   5
    14500.      600.    45400.   100000.    14500.      600.    45400.   100000.    BC   5
      600.    592.24      500.    507.76      600.     1100.     1100.              BC   6
   3602.41   2502.41   1525.89   3414.81   3407.05   2814.81   2814.81   2314.81    BC   6
   2307.05   2819.67   1719.67    425.89                                            BC   7
        .3        .3        .3        .3        .3        .3        .3        .3    BC   7
       .03       .15       .03       .15        .3       .03        .3              BC   8
        0.        0.        0.        0.        0.        0.        0.        0.    BC   8
        1.       .67        1.        1.        1.        1.        0.              BC   9
    5   13  -12    7    8   15                                                      BC   9
    1                                                                               BC  10
      100.     AA100         1         0     1.E20      1.E3                        BC  12
                            .3        .3        .3                                  BC  12
      2.E4      100.                                                                BC  13
                                                                                    BC  14
                1.E5                                                                BC  15
1             1                                                                     BC  18
    11                                                                              BC   0
                    600.      8000.                                                 BC   2
                1.E5                                                                BC  15
             1                                                                      BC  18
                    600.       50.                                                  BC   0
                1.E5                                                                BC  15
1                                                                                   BC  18
    11     1                                                                        BC   0
               1.5E5                                                                BC   2
                                                                                    BC  18
```

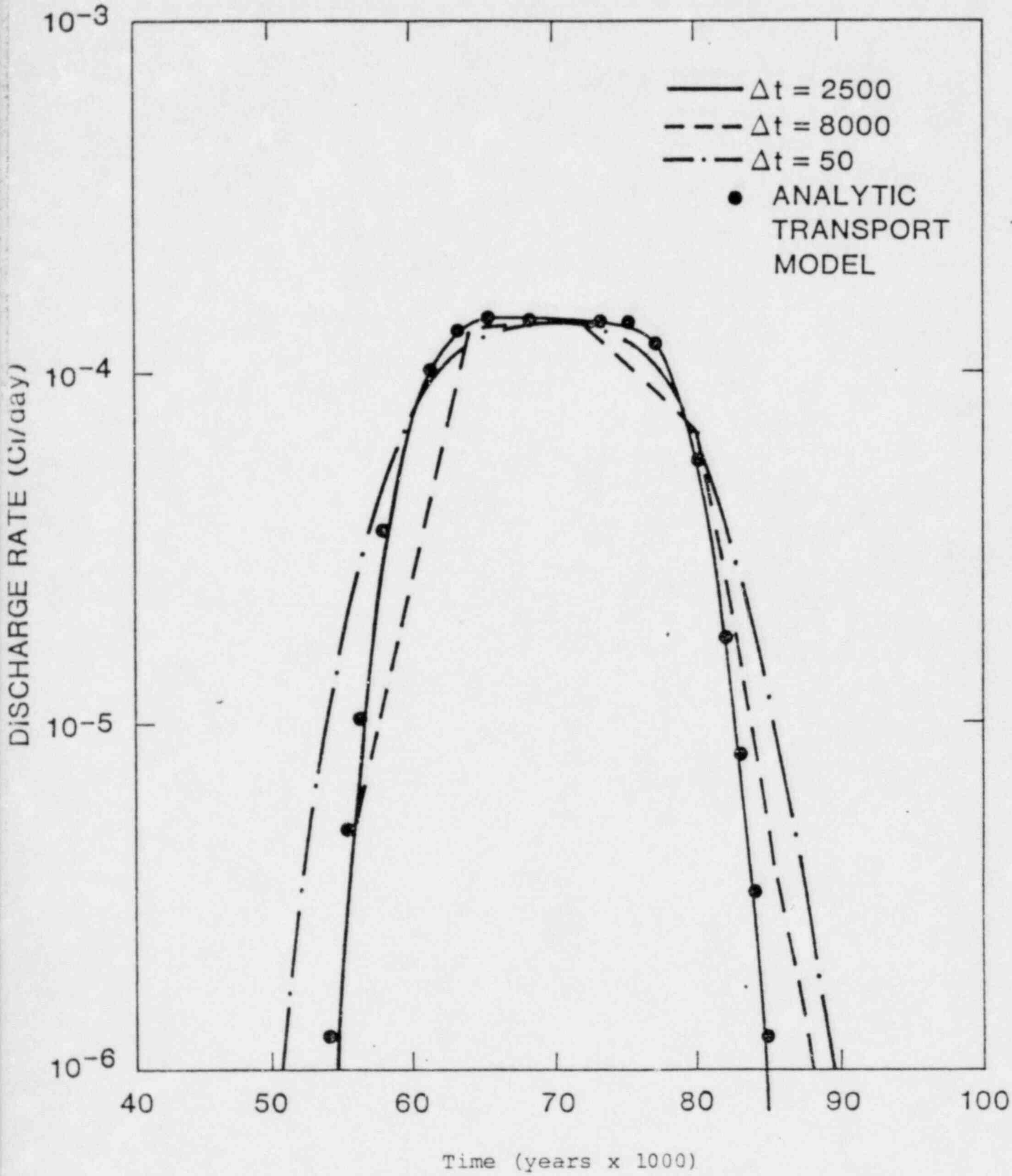


Figure 9-SP. Discharge Rates vs. Time for Problem 5

OPTIONS 1,0 2,0 3,0 4,0 5,0 6,0 7,0 8,0 9,0 10,0 11,0 12,0 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0

NUMBER OF ISOTOPES 1

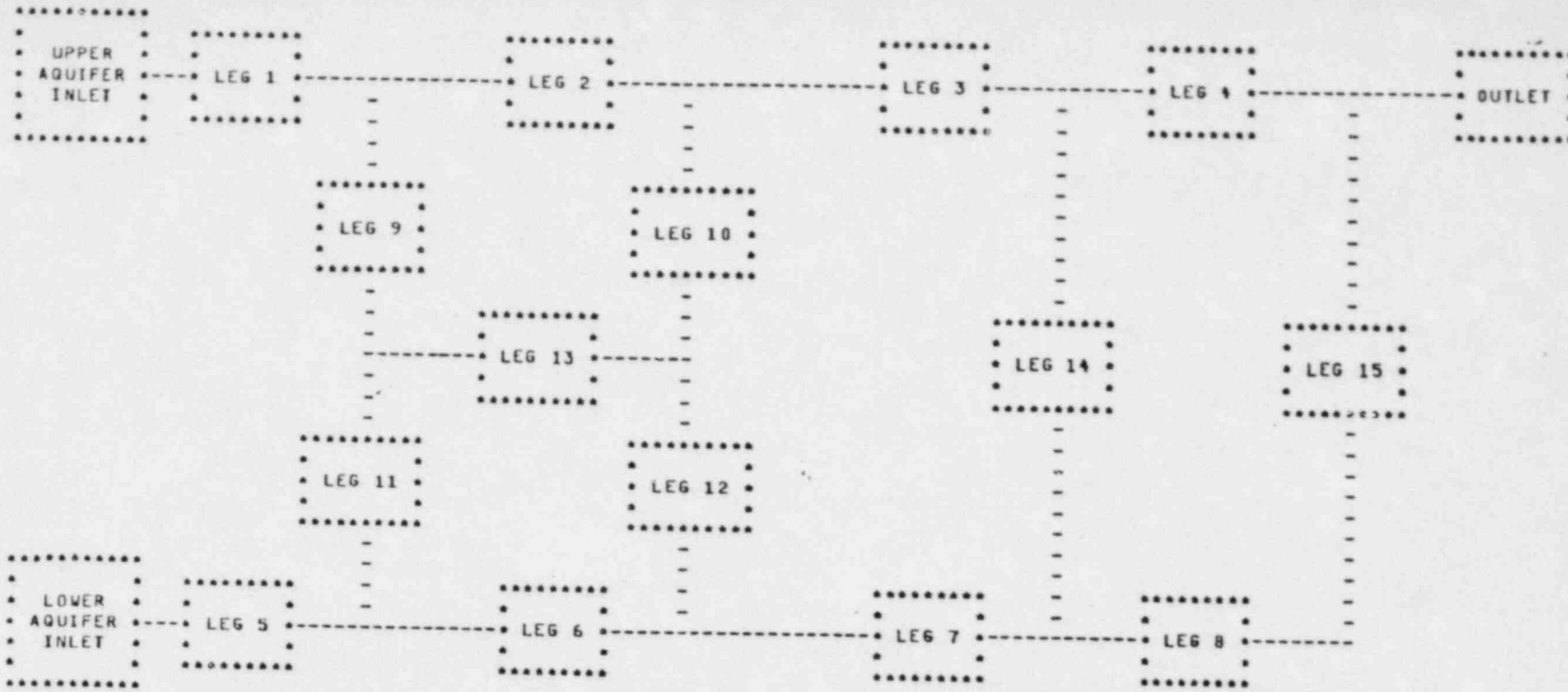
ISOTOPE NAME	HALF LIFE (YEARS)	INITIAL AMOUNT (CI)
AA100	1.000E+20	1.000E+03

LEACH TIME = 2.000E+04 YEARS DISPERSIVITY = 1.000E+02 FEET

NO OF VECTORS = 0 TIME UPPER BOUND = 1.00E+05

Table 12-SP. Sample Problem 5 Output

(Pages 169 through 214 inclusive)



------RADIONUCLIDE MIGRATION PATH------LEGS 13 -12 7 8 15

UPPER AQUIFER INLET
INLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 3602.41 FT

LOWER AQUIFER INLET
INLET PRESSURE = 93038.40 LB/FT**2
ELEVATION = 2502.41 FT

OUTLET
OUTLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 1525.89 FT

ELEVATIONS OF OTHER POINTS

JUNCTION 4 (LEGS 1-2-9) =	3414.81 FT
JUNCTION 5 (LEGS 2-3-10) =	3407.05 FT
JUNCTION 6 (LEGS 9-11-13) =	2814.81 FT
JUNCTION 7 (LEGS 10-12-13) =	2814.81 FT
JUNCTION 8 (LEGS 5-6-11) =	2314.81 FT
JUNCTION 9 (LEGS 6-7-12) =	2307.05 FT
JUNCTION10 (LEGS 3-4-14) =	2819.67 FT
JUNCTION11 (LEGS 7-8-14) =	1719.67 FT
JUNCTION12 (LEGS 8-15) =	425.89 FT

LEG PROPERTIES

LEG 1
****
LENGTH = 1.45E+04 FT
AREA = 6.00E+06 FT**2

```
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  2
********
             LENGTH =  6.00E+02 FT
               AREA =  6.00E+06 FT**2
       CONDUCTIVITY =  1.83E+04 FT/YR
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  3
********
             LENGTH =  4.54E+04 FT
               AREA =  6.00E+06 FT**2
       CONDUCTIVITY =  1.83E+04 FT/YR
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  4
********
             LENGTH =  1.00E+05 FT
               AREA =  6.00E+06 FT**2
       CONDUCTIVITY =  1.83E+04 FT/YR
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  5
********
             LENGTH =  1.45E+04 FT
               AREA =  1.80E+06 FT**2
       CONDUCTIVITY =  1.46E+04 FT/YR
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  6
********
             LENGTH =  6.00E+02 FT
               AREA =  1.80E+06 FT**2
       CONDUCTIVITY =  1.46E+04 FT/YR
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP

                LEG PROPERTIES

LEG  7
********
             LENGTH =  4.54E+04 FT
               AREA =  1.80E+06 FT**2
       CONDUCTIVITY =  1.46E+04 FT/YR
           POROSITY =    .3000
       ROCK DENSITY =  1.19E+02 LB/FT**3
      FLUID DENSITY =  6.23E+01 LB/FT**3
    FLUID VISCOSITY =  1.00E+00 CP
```

LEG 8
....

LENGTH = 1.00E+05 FT
AREA = 1.80E+06 FT**2
CONDUCTIVITY = 1.46E+04 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

LEG PROPERTIES

LEG 9
....

LENGTH = 6.00E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.48E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 10
....

LENGTH = 5.92E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 3.65E+03 FT/YR
POROSITY = .1500
ROCK DENSITY = 1.45E+02 LB/FT**3
FLUID DENSITY = 7.02E+01 LB/FT**3
FLUID VISCOSITY = 1.27E+00 CP

LEG PROPERTIES

LEG 11
....

LENGTH = 5.00E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 6.10E-04 FT/YR
POROSITY = .0300
ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 12
....

LENGTH = 5.08E+02 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 3.65E+03 FT/YR
POROSITY = .1500
ROCK DENSITY = 1.45E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 13
....

LENGTH = 6.00E+02 FT
AREA = 1.01E+04 FT**2
CONDUCTIVITY = 3.65E+03 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 14
....

LENGTH = 1.10E+03 FT
AREA = 1.00E+00 FT**2
CONDUCTIVITY = 5.73E-04 FT/YR
POROSITY = .0300

FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 15
****

LENGTH = 1.10E+03 FT
AREA = 1.20E+08 FT**2
CONDUCTIVITY = 9.13E+02 FT/YR
POROSITY = .3000
ROCK DENSITY = 1.19E+02 LB/FT**3
FLUID DENSITY = 6.23E+01 LB/FT**3
FLUID VISCOSITY = 1.00E+00 CP

DISTRIBUTION COEFFICIENTS BY LEG AND BY ISOTOPE

	AA100
LEG13	0.
LEG12	0.
LEG 7	.30000E+00
LEG 8	.30000E+00
LEG15	.30000E+00

RETARDATION FACTORS BY LEG AND BY ISOTOPE

	AA100
LEG13	.10000E+01
LEG12	.10000E+01
LEG 7	.12000E+03
LEG 8	.12000E+03
LEG15	.12000E+03

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LEG NO.	FLOW VOL. (CU FT)/DAY	DARCY VEL. FT/DAY	PORE VEL. FT/DAY
1	3.88E+06	6.47E-01	2.16E+00
2	3.88E+06	6.47E-01	2.16E+00
3	3.88E+06	6.47E-01	2.16E+00
4	3.88E+06	6.47E-01	2.16E+00
5	6.58E+05	3.66E-01	1.22E+00
6	6.58E+05	3.66E-01	1.22E+00
7	6.58E+05	3.66E-01	1.22E+00
8	6.58E+05	3.66E-01	1.22E+00
9	-7.22E-07	-7.22E-07	-2.41E-05
10	-4.87E+00	-4.87E+00	-3.24E+01
11	-8.09E-07	-8.09E-07	-2.70E-05
12	-4.87E+00	-4.87E+00	-3.24E+01
13	-8.79E-08	-8.72E-12	-2.91E-11
14	-5.83E-07	-5.83E-07	-1.94E-05
15	6.58E+05	5.48E-03	1.83E-02

TOTAL PATH LENGTH (FT) = 1.4761E+05
FROM DEPOSITORY MIDPT (FT) = 1.4731E+05
AVERAGE FLUID VELOCITY (FT/Y) = 1.4695E+02

THE SPACE STEP................ DX = 6.00000E+02 FT
THE TIME STEP................. DT = 2.50000E+03 Y
NO OF SOURCE BLKS............. NSB = 1

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER

AA100.	(DECAY)	.24753E+01	.1000UE+01	.10355E+02

YEAR	AA100
5000.	0.
7500.	0.
10000.	0.
12500.	0.
15000.	0.
17500.	0.
20000.	0.
22500.	0.
25000.	0.
27500.	0.
30000.	0.
32500.	0.
35000.	0.
37500.	0.
40000.	0.
42500.	0.
45000.	.51656E-29
47500.	.97534E-17
50000.	.57348E-11
52500.	.12927E-07
55000.	.14455E-05
57500.	.21874E-04
60000.	.81388E-04
62500.	.12634E-03
65000.	.13629E-03
67500.	.13697E-03
70000.	.13699E-03
72500.	.13697E-03
75000.	.13554E-03
77500.	.11511E-03
80000.	.55599E-04
82500.	.10650E-04
85000.	.70096E-06
87500.	.15153E-07
90000.	.10424E-09
92500.	.21656E-12
95000.	.12389E-15
97500.	.16709E-19
100000.	.40943E-24

OPTIONS 1,0 2,0 3,0 4,0 5,0 6,1 7,1 8,0 9,0 10,0 11,0 12,0 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0

NO OF VECTORS = 0 TIME UPPER BOUND = 1.00E+05

THE SPACE STEP................ DX = 6.00000E+02 FT
THE TIME STEP................. DT = 8.00000E+03 Y
NO OF SOURCE BLKS............. NSB = 1

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER
AA100	(DECAY)	.24753E+01	.10000E+01	.33137E+02

```
 F.AM      AA100
 16000.  0.
 24000.  0.
 32000.  0.
 40000.  0.
 48000.  0.
 56000.   .49058E-05
 64000.   .13490E-03
 72000.   .13453E-03
 80000.   .67082E-04
 88000.   .10419E-05
 96000.  0.
104000.  0.

NO OF VECTORS =    0 TIME UPPER BOUND =          1.00E+05

                  THE SPACE STEP...............  DX   = 6.00000E+02 FT
                  THE TIME STEP................  DT   = 5.00000E+01 Y
                  NO OF SOURCE BLKS............  NSB =     1

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED
 DAUGHTER               PARENT(S)
                                          AVERAGE VELOCITY       DECAY/PRODUCTION FACTOR(DT)     COURANT NUMBER
  AA100                 (DECAY)
                                            .24753E+01                 .10000E+01                  .20710E+00
```

YEAR	AA100
100.	0.
150.	0.
200.	0.
250.	0.
300.	0.
350.	0.
400.	0.
450.	0.
500.	0.
550.	0.
600.	0.
650.	0.
700.	0.
750.	0.
800.	0.
850.	0.
900.	0.
950.	0.
1000.	0.
1050.	0.
1100.	0.
1150.	0.
1200.	0.
1250.	0.
1300.	0.
1350.	0.
1400.	0.
1450.	0.
1500.	0.
1550.	0.
1600.	0.
1650.	0.
1700.	0.
1750.	0.
1800.	0.
1850.	0.
1900.	0.
1950.	0.
2000.	0.
2050.	0.
2100.	0.
2150.	0.
2200.	0.
2250.	0.
2300.	0.
2350.	0.
2400.	0.
2450.	0.
2500.	0.
2550.	0.
2600.	0.
2650.	0.
2700.	0.
2750.	0.
2800.	0.
2850.	0.
2900.	0.
2950.	0.
3000.	0.
3050.	0.

[illegible]	A*100
3100.	0.
3150.	0.
3200.	0.
3250.	0.
3300.	0.
3350.	0.
3400.	0.
3450.	0.
3500.	0.
3550.	0.
3600.	0.
3650.	0.
3700.	0.
3750.	0.
3800.	0.
3850.	0.
3900.	0.
3950.	0.
4000.	0.
4050.	0.
4100.	0.
4150.	0.
4200.	0.
4250.	0.
4300.	0.
4350.	0.
4400.	0.
4450.	0.
4500.	0.
4550.	0.
4600.	0.
4650.	0.
4700.	0.
4750.	0.
4800.	0.
4850.	0.
4900.	0.
4950.	0.
5000.	0.
5050.	0.
5100.	0.
5150.	0.
5200.	0.
5250.	0.
5300.	0.
5350.	0.
5400.	0.
5450.	0.
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5550.	0.
5600.	0.
5650.	0.
5700.	0.
5750.	0.
5800.	0.
5850.	0.
5900.	0.
5950.	0.
6000.	0.
6050.	0.

YEAR	AA100
6100.	0.
6150.	0.
6200.	0.
6250.	0.
6300.	0.
6350.	0.
6400.	0.
6450.	0.
6500.	0.
6550.	0.
6600.	0.
6650.	0.
6700.	0.
6750.	0.
6800.	0.
6850.	0.
6900.	0.
6950.	0.
7000.	0.
7050.	0.
7100.	0.
7150.	0.
7200.	0.
7250.	0.
7300.	0.
7350.	0.
7400.	0.
7450.	0.
7500.	0.
7550.	0.
7600.	0.
7650.	0.
7700.	0.
7750.	0.
7800.	0.
7850.	0.
7900.	0.
7950.	0.
8000.	0.
8050.	0.
8100.	0.
8150.	0.
8200.	0.
8250.	0.
8300.	0.
8350.	0.
8400.	0.
8450.	0.
8500.	0.
8550.	0.
8600.	0.
8650.	0.
8700.	0.
8750.	0.
8800.	0.
8850.	0.
8900.	0.
8950.	0.
9000.	0.
9050.	0.

YEAR	AA100
9100.	0.
9150.	0.
9200.	0.
9250.	0.
9300.	0.
9350.	0.
9400.	0.
9450.	0.
9500.	0.
9550.	0.
9600.	0.
9650.	0.
9700.	0.
9750.	0.
9800.	0.
9850.	0.
9900.	0.
9950.	0.
10000.	0.
10050.	0.
10100.	0.
10150.	0.
10200.	0.
10250.	0.
10300.	0.
10350.	0.
10400.	0.
10450.	0.
10500.	0.
10550.	0.
10600.	0.
10650.	0.
10700.	0.
10750.	0.
10800.	0.
10850.	0.
10900.	0.
10950.	0.
11000.	0.
11050.	0.
11100.	0.
11150.	0.
11200.	0.
11250.	0.
11300.	0.
11350.	0.
11400.	0.
11450.	0.
11500.	0.
11550.	0.
11600.	0.
11650.	0.
11700.	0.
11750.	0.
11800.	0.
11850.	0.
11900.	0.
11950.	0.
12000.	0.
12050.	0.

T.AR	AA100
12100.	0.
12150.	0.
12200.	0.
12250.	0.
12300.	0.
12350.	0.
12400.	0.
12450.	0.
12500.	0.
12550.	0.
12600.	0.
12650.	0.
12700.	0.
12750.	0.
12800.	0.
12850.	0.
12900.	0.
12950.	0.
13000.	0.
13050.	0.
13100.	0.
13150.	0.
13200.	0.
13250.	0.
13300.	0.
13350.	0.
13400.	0.
13450.	0.
13500.	0.
13550.	0.
13600.	0.
13650.	0.
13700.	0.
13750.	0.
13800.	0.
13850.	0.
13900.	0.
13950.	0.
14000.	0.
14050.	0.
14100.	0.
14150.	0.
14200.	0.
14250.	0.
14300.	0.
14350.	0.
14400.	0.
14450.	0.
14500.	0.
14550.	0.
14600.	0.
14650.	0.
14700.	0.
14750.	0.
14800.	0.
14850.	0.
14900.	0.
14950.	0.
15000.	0.
15050.	0.

[illegible]	[illegible]
15100.	0.
15150.	0.
15200.	0.
15250.	0.
15300.	0.
15350.	0.
15400.	0.
15450.	0.
15500.	0.
15550.	0.
15600.	0.
15650.	0.
15700.	0.
15750.	0.
15800.	0.
15850.	0.
15900.	0.
15950.	0.
16000.	0.
16050.	0.
16100.	0.
16150.	0.
16200.	0.
16250.	0.
16300.	0.
16350.	0.
16400.	0.
16450.	0.
16500.	0.
16550.	0.
16600.	0.
16650.	0.
16700.	0.
16750.	0.
16800.	0.
16850.	0.
16900.	0.
16950.	0.
17000.	0.
17050.	0.
17100.	0.
17150.	0.
17200.	0.
17250.	0.
17300.	0.
17350.	0.
17400.	0.
17450.	0.
17500.	0.
17550.	0.
17600.	0.
17650.	0.
17700.	0.
17750.	0.
17800.	0.
17850.	0.
17900.	0.
17950.	0.
18000.	0.
18050.	0.

[illegible]	[illegible]
18100.	0.
18150.	0.
18200.	0.
18250.	0.
18300.	0.
18350.	0.
18400.	0.
18450.	0.
18500.	0.
18550.	0.
18600.	0.
18650.	0.
18700.	0.
18750.	0.
18800.	0.
18850.	0.
18900.	0.
18950.	0.
19000.	0.
19050.	0.
19100.	0.
19150.	0.
19200.	0.
19250.	0.
19300.	0.
19350.	0.
19400.	0.
19450.	0.
19500.	0.
19550.	0.
19600.	0.
19650.	0.
19700.	0.
19750.	0.
19800.	0.
19850.	0.
19900.	0.
19950.	0.
20000.	0.
20050.	0.
20100.	0.
20150.	0.
20200.	0.
20250.	0.
20300.	0.
20350.	0.
20400.	0.
20450.	0.
20500.	0.
20550.	0.
20600.	0.
20650.	0.
20700.	0.
20750.	0.
20800.	0.
20850.	0.
20900.	0.
20950.	0.
21000.	0.
21050.	0.

XLAM	24100
21100.	0.
21150.	0.
21200.	0.
21250.	0.
21300.	0.
21350.	0.
21400.	0.
21450.	0.
21500.	0.
21550.	0.
21600.	0.
21650.	0.
21700.	0.
21750.	0.
21800.	0.
21850.	0.
21900.	0.
21950.	0.
22000.	0.
22050.	0.
22100.	0.
22150.	0.
22200.	0.
22250.	0.
22300.	0.
22350.	0.
22400.	0.
22450.	0.
22500.	0.
22550.	0.
22600.	0.
22650.	0.
22700.	0.
22750.	0.
22800.	0.
22850.	0.
22900.	0.
22950.	0.
23000.	0.
23050.	0.
23100.	0.
23150.	0.
23200.	0.
23250.	0.
23300.	0.
23350.	0.
23400.	0.
23450.	0.
23500.	0.
23550.	0.
23600.	0.
23650.	0.
23700.	0.
23750.	0.
23800.	0.
23850.	0.
23900.	0.
23950.	0.
24000.	0.
24050.	0.

YEAR	AA100
24100.	0.
24150.	0.
24200.	0.
24250.	0.
24300.	0.
24350.	0.
24400.	0.
24450.	0.
24500.	0.
24550.	0.
24600.	0.
24650.	0.
24700.	0.
24750.	0.
24800.	0.
24850.	0.
24900.	0.
24950.	0.
25000.	0.
25050.	0.
25100.	0.
25150.	0.
25200.	0.
25250.	0.
25300.	0.
25350.	0.
25400.	0.
25450.	0.
25500.	0.
25550.	.16236E-40
25600.	.23911E-40
25650.	.35024E-40
25700.	.51212E-40
25750.	.74755E-40
25800.	.10894E-39
25850.	.15848E-39
25900.	.23016E-39
25950.	.33371E-39
26000.	.48303E-39
26050.	.69803E-39
26100.	.10071E-38
26150.	.14505E-38
26200.	.20859E-38
26250.	.29947E-38
26300.	.42926E-38
26350.	.61431E-38
26400.	.87775E-38
26450.	.12522E-37
26500.	.17835E-37
26550.	.25364E-37
26600.	.36015E-37
26650.	.51059E-37
26700.	.72276E-37
26750.	.10215E-36
26800.	.14416E-36
26850.	.20314E-36
26900.	.28582E-36
26950.	.40155E-36
27000.	.56330E-36
27050.	.78904E-36

TLAR	AA100
27100.	.11036E-35
27150.	.15414E-35
27200.	.21496E-35
27250.	.29936E-35
27300.	.41629E-35
27350.	.57808E-35
27400.	.80159E-35
27450.	.11100E-34
27500.	.15348E-34
27550.	.21193E-34
27600.	.29223E-34
27650.	.40239E-34
27700.	.55333E-34
27750.	.75984E-34
27800.	.10420E-33
27850.	.14270E-33
27900.	.19517E-33
27950.	.26656E-33
28000.	.36359E-33
28050.	.49528E-33
28100.	.67377E-33
28150.	.91540E-33
28200.	.12420E-32
28250.	.16831E-32
28300.	.22778E-32
28350.	.30786E-32
28400.	.41557E-32
28450.	.56025E-32
28500.	.75434E-32
28550.	.10144E-31
28600.	.13624E-31
28650.	.18275E-31
28700.	.24484E-31
28750.	.32762E-31
28800.	.43784E-31
28850.	.58443E-31
28900.	.77916E-31
28950.	.10375E-30
29000.	.13799E-30
29050.	.18330E-30
29100.	.24320E-30
29150.	.32230E-30
29200.	.42662E-30
29250.	.56405E-30
29300.	.74487E-30
29350.	.98251E-30
29400.	.12945E-29
29450.	.17035E-29
29500.	.22393E-29
29550.	.29402E-29
29600.	.38562E-29
29650.	.50517E-29
29700.	.66106E-29
29750.	.86407E-29
29800.	.11282E-28
29850.	.14714E-28
29900.	.19169E-28
29950.	.24946E-28
30000.	.32428E-28
30050.	.42108E-28

ELAM	AA100
30100.	.54620E-28
30150.	.70772E-28
30200.	.91604E-28
30250.	.11844E-27
30300.	.15298E-27
30350.	.19738E-27
30400.	.25440E-27
30450.	.32754E-27
30500.	.42129E-27
30550.	.54130E-27
30600.	.69478E-27
30650.	.89087E-27
30700.	.11411E-26
30750.	.14602E-26
30800.	.18667E-26
30850.	.23838E-26
30900.	.30412E-26
30950.	.38759E-26
31000.	.49350E-26
31050.	.62771E-26
31100.	.79765E-26
31150.	.10126E-25
31200.	.12842E-25
31250.	.16271E-25
31300.	.20596E-25
31350.	.26045E-25
31400.	.32905E-25
31450.	.41531E-25
31500.	.52369E-25
31550.	.65973E-25
31600.	.83033E-25
31550.	.10441E-24
31700.	.13116E-24
31750.	.16462E-24
31800.	.20642E-24
31850.	.25859E-24
31900.	.32366E-24
31950.	.40473E-24
32000.	.50565E-24
32050.	.63117E-24
32100.	.78713E-24
32150.	.98076E-24
32200.	.12209E-23
32250.	.15186E-23
32300.	.18871E-23
32350.	.23429E-23
32400.	.29064E-23
32450.	.36023E-23
32500.	.44608E-23
32550.	.55192E-23
32600.	.68229E-23
32650.	.84273E-23
32700.	.10400E-22
32750.	.12824E-22
32800.	.15799E-22
32850.	.19448E-22
32900.	.23920E-22
32950.	.29395E-22
33000.	.36094E-22
33050.	.44283E-22

[illegible] DISCHARGE RATE (CI/DAY)

YEAR	AA100
33100.	.54285E-22
33150.	.66491E-22
33200.	.81376E-22
33250.	.99511E-22
33300.	.12159E-21
33350.	.14845E-21
33400.	.18109E-21
33450.	.22074E-21
33500.	.26885E-21
33550.	.32718E-21
33600.	.39786E-21
33650.	.48343E-21
33700.	.58694E-21
33750.	.71206E-21
33800.	.86318E-21
33850.	.10456E-20
33900.	.12655E-20
33950.	.15305E-20
34000.	.18497E-20
34050.	.22336E-20
34100.	.26953E-20
34150.	.32498E-20
34200.	.39156E-20
34250.	.47142E-20
34300.	.56714E-20
34350.	.68179E-20
34400.	.81902E-20
34450.	.98313E-20
34500.	.11793E-19
34550.	.14135E-19
34600.	.16930E-19
34650.	.20264E-19
34700.	.24236E-19
34750.	.28966E-19
34800.	.34594E-19
34850.	.41287E-19
34900.	.49239E-19
34950.	.58682E-19
35000.	.69885E-19
35050.	.83170E-19
35100.	.98911E-19
35150.	.11755E-18
35200.	.13960E-18
35250.	.16568E-18
35300.	.19649E-18
35350.	.23287E-18
35400.	.27580E-18
35450.	.32642E-18
35500.	.38606E-18
35550.	.45631E-18
35600.	.53896E-18
35650.	.63617E-18
35700.	.75040E-18
35750.	.88457E-18
35800.	.10420E-17
35850.	.12267E-17
35900.	.14432E-17
35950.	.16967E-17
36000.	.19935E-17
36050.	.23407E-17

YEAR	AA100
36100.	.27465E-17
36150.	.32207E-17
36200.	.37743E-17
36250.	.44203E-17
36300.	.51735E-17
36350.	.60512E-17
36400.	.70733E-17
36450.	.82629E-17
36500.	.96465E-17
36550.	.11255E-16
36600.	.13123E-16
36650.	.15292E-16
36700.	.17808E-16
36750.	.20726E-16
36800.	.24106E-16
36850.	.28021E-16
36900.	.32553E-16
36950.	.37794E-16
37000.	.43852E-16
37050.	.50851E-16
37100.	.58931E-16
37150.	.68255E-16
37200.	.79006E-16
37250.	.91398E-16
37300.	.10567E-15
37350.	.12210E-15
37400.	.14100E-15
37450.	.16273E-15
37500.	.18770E-15
37550.	.21638E-15
37600.	.24930E-15
37650.	.28706E-15
37700.	.33034E-15
37750.	.37994E-15
37800.	.43674E-15
37850.	.50174E-15
37900.	.57609E-15
37950.	.66109E-15
38000.	.75820E-15
38050.	.86909E-15
38100.	.99564E-15
38150.	.11400E-14
38200.	.13046E-14
38250.	.14920E-14
38300.	.17055E-14
38350.	.19485E-14
38400.	.22249E-14
38450.	.25391E-14
38500.	.28962E-14
38550.	.33016E-14
38600.	.37618E-14
38650.	.42838E-14
38700.	.48757E-14
38750.	.55464E-14
38800.	.63061E-14
38850.	.71660E-14
38900.	.81389E-14
38950.	.92390E-14
39000.	.10482E-13
39050.	.11887E-13

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
39100.	.13473E-13
39150.	.15262E-13
39200.	.17280E-13
39250.	.19555E-13
39300.	.22118E-13
39350.	.25005E-13
39400.	.28254E-13
39450.	.31908E-13
39500.	.36018E-13
39550.	.40636E-13
39600.	.45824E-13
39650.	.51648E-13
39700.	.58183E-13
39750.	.65513E-13
39800.	.73730E-13
39850.	.82937E-13
39900.	.93247E-13
39950.	.10479E-12
40000.	.11770E-12
40050.	.13214E-12
40100.	.14828E-12
40150.	.16631E-12
40200.	.18645E-12
40250.	.20892E-12
40300.	.23399E-12
40350.	.26194E-12
40400.	.29309E-12
40450.	.32780E-12
40500.	.36644E-12
40550.	.40944E-12
40600.	.45728E-12
40650.	.51047E-12
40700.	.56958E-12
40750.	.63524E-12
40800.	.70815E-12
40850.	.78907E-12
40900.	.87882E-12
40950.	.97835E-12
41000.	.10886E-11
41050.	.12108E-11
41100.	.13461E-11
41150.	.14959E-11
41200.	.16615E-11
41250.	.18447E-11
41300.	.20471E-11
41350.	.22708E-11
41400.	.25178E-11
41450.	.27904E-11
41500.	.30912E-11
41550.	.34229E-11
41600.	.37886E-11
41650.	.41915E-11
41700.	.46352E-11
41750.	.51237E-11
41800.	.56613E-11
41850.	.62526E-11
41900.	.69026E-11
41950.	.76171E-11
42000.	.84019E-11
42050.	.92636E-11

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
42100.	.10209E-10
42150.	.11247E-10
42200.	.12385E-10
42250.	.13632E-10
42300.	.14999E-10
42350.	.16496E-10
42400.	.18135E-10
42450.	.19929E-10
42500.	.21891E-10
42550.	.24036E-10
42500.	.26381E-10
42550.	.28942E-10
42700.	.31740E-10
42750.	.34794E-10
42800.	.38126E-10
42850.	.41761E-10
42900.	.45724E-10
42950.	.50043E-10
43000.	.54749E-10
43050.	.59873E-10
43100.	.65451E-10
43150.	.71521E-10
43200.	.78123E-10
43250.	.85301E-10
43300.	.93102E-10
43350.	.10158E-09
43400.	.11078E-09
43450.	.12077E-09
43500.	.13161E-09
43550.	.14337E-09
43500.	.15613E-09
43650.	.16995E-09
43700.	.18492E-09
43750.	.20114E-09
43800.	.21869E-09
43850.	.23769E-09
43900.	.25825E-09
43950.	.28048E-09
44000.	.30450E-09
44050.	.33047E-09
44100.	.35851E-09
44150.	.38879E-09
44200.	.42147E-09
44250.	.45673E-09
44300.	.49477E-09
44350.	.53577E-09
44400.	.57997E-09
44450.	.62758E-09
44500.	.67885E-09
44550.	.73405E-09
44600.	.79346E-09
44650.	.85737E-09
44700.	.92609E-09
44750.	.99997E-09
44800.	.10794E-08
44850.	.11646E-08
44900.	.12562E-08
44950.	.13545E-08
45000.	.14600E-08
45050.	.15732E-08

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
45100.	.16945E-08
45150.	.18246E-08
45200.	.19640E-08
45250.	.21133E-08
45300.	.22732E-08
45350.	.24443E-08
45400.	.26275E-08
45450.	.28234E-08
45500.	.30328E-08
45550.	.32568E-08
45600.	.34960E-08
45650.	.37516E-08
45700.	.40246E-08
45750.	.43159E-08
45800.	.46269E-08
45850.	.49586E-08
45900.	.53123E-08
45950.	.56894E-08
46000.	.60912E-08
46050.	.65193E-08
46100.	.69752E-08
46150.	.74606E-08
46200.	.79772E-08
46250.	.85269E-08
46300.	.91114E-08
46350.	.97329E-08
46400.	.10394E-07
46450.	.11095E-07
46500.	.11841E-07
46550.	.12633E-07
46600.	.13473E-07
46650.	.14365E-07
46700.	.15311E-07
46750.	.16314E-07
46800.	.17377E-07
46850.	.18504E-07
46900.	.19699E-07
46950.	.20963E-07
47000.	.22302E-07
47050.	.23719E-07
47100.	.25219E-07
47150.	.26805E-07
47200.	.28482E-07
47250.	.30255E-07
47300.	.32129E-07
47350.	.34109E-07
47400.	.36199E-07
47450.	.38407E-07
47500.	.40737E-07
47550.	.43195E-07
47600.	.45789E-07
47650.	.48523E-07
47700.	.51406E-07
47750.	.54444E-07
47800.	.57645E-07
47850.	.61016E-07
47900.	.64566E-07
47950.	.63303E-07
48000.	.72234E-07
48050.	.76371E-07

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
48100.	.80721E-07
48150.	.85294E-07
48200.	.90101E-07
48250.	.95151E-07
48300.	.10046E-06
48350.	.10603E-06
48400.	.11188E-06
48450.	.11801E-06
48500.	.12445E-06
48550.	.13121E-06
48600.	.13829E-06
48650.	.14572E-06
48700.	.15350E-06
48750.	.16165E-06
48900.	.17019E-06
48850.	.17913E-06
48900.	.18849E-06
48950.	.19829E-06
49000.	.20853E-06
49050.	.21925E-06
49100.	.23046E-06
49150.	.24217E-06
49200.	.25441E-06
49250.	.26720E-06
49300.	.28056E-06
49350.	.29450E-06
49400.	.30906E-06
49450.	.32426E-06
49500.	.34011E-06
49550.	.35664E-06
49600.	.37388E-06
49550.	.39185E-06
49700.	.41057E-06
49750.	.43008E-06
49800.	.45041E-06
49850.	.47157E-06
[illegible]	.49360E-06
49950.	.51652E-06
50000.	.54038E-06
50050.	.56519E-06
50100.	.59099E-06
50150.	.61782E-06
50200.	.64570E-06
50250.	.67467E-06
50300.	.70476E-06
50350.	.73602E-06
50400.	.76847E-06
50450.	.80215E-06
50500.	.83710E-06
50550.	.87336E-06
50600.	.91097E-06
50650.	.94997E-06
50700.	.99040E-06
50750.	.10323E-05
50800.	.10757E-05
50850.	.11207E-05
50900.	.11672E-05
50950.	.12154E-05
51000.	.12653E-05
51050.	.13170E-05

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
51100.	.13704E-05
51150.	.14257E-05
51200.	.14828E-05
51250.	.15418E-05
51300.	.16029E-05
51350.	.16659E-05
51400.	.17311E-05
51450.	.17984E-05
51500.	.18678E-05
51550.	.19395E-05
51600.	.20135E-05
51650.	.20898E-05
51700.	.21686E-05
51750.	.22498E-05
51800.	.23335E-05
51850.	.24197E-05
51900.	.25086E-05
51950.	.26002E-05
52000.	.26945E-05
52050.	.27917E-05
52100.	.28916E-05
52150.	.29946E-05
52200.	.31004E-05
52250.	.32094E-05
52300.	.33214E-05
52350.	.34366E-05
52400.	.35550E-05
52450.	.36767E-05
52500.	.38018E-05
52550.	.39303E-05
52600.	.40622E-05
52650.	.41977E-05
52700.	.43367E-05
52750.	.44794E-05
52800.	.46259E-05
52850.	.47761E-05
52900.	.49302E-05
52950.	.50882E-05
53000.	.52501E-05
53050.	.54161E-05
53100.	.55862E-05
53150.	.57604E-05
53200.	.59389E-05
53250.	.61216E-05
53300.	.63087E-05
53350.	.65001E-05
53400.	.66961E-05
53450.	.68965E-05
53500.	.71015E-05
53550.	.73112E-05
53600.	.75255E-05
53650.	.77446E-05
53700.	.79684E-05
53750.	.81972E-05
53800.	.84308E-05
53850.	.86694E-05
53900.	.89130E-05
53950.	.91617E-05
54000.	.94155E-05
54050.	.96744E-05

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
54100.	.99386E-05
54150.	.10208E-04
54200.	.10483E-04
54250.	.10763E-04
54300.	.11048E-04
54350.	.11339E-04
54400.	.11636E-04
54450.	.11938E-04
54500.	.12245E-04
54550.	.12558E-04
54600.	.12877E-04
54650.	.13201E-04
54700.	.13531E-04
54750.	.13867E-04
54800.	.14208E-04
54850.	.14555E-04
54900.	.14908E-04
54950.	.15267E-04
55000.	.15632E-04
55050.	.16002E-04
55100.	.16379E-04
55150.	.16761E-04
55200.	.17149E-04
55250.	.17543E-04
55300.	.17943E-04
55350.	.18349E-04
55400.	.18761E-04
55450.	.19178E-04
55500.	.19602E-04
55550.	.20031E-04
55600.	.20467E-04
55650.	.20908E-04
55700.	.21356E-04
55750.	.21809E-04
55800.	.22268E-04
55850.	.22733E-04
55900.	.23203E-04
55950.	.23680E-04
56000.	.24162E-04
56050.	.24650E-04
56100.	.25144E-04
56150.	.25644E-04
56200.	.26149E-04
56250.	.26660E-04
56300.	.27176E-04
56350.	.27698E-04
56400.	.28226E-04
56450.	.28759E-04
56500.	.29297E-04
56550.	.29841E-04
56600.	.30390E-04
56650.	.30945E-04
56700.	.31505E-04
56750.	.32069E-04
56800.	.32639E-04
56850.	.33214E-04
56900.	.33794E-04
56950.	.34379E-04
57000.	.34969E-04
57050.	.35564E-04

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
57100.	.36163E-04
57150.	.36767E-04
57200.	.37375E-04
57250.	.37988E-04
57300.	.38605E-04
57350.	.39226E-04
57400.	.39852E-04
57450.	.40482E-04
57500.	.41116E-04
57550.	.41754E-04
57600.	.42395E-04
57650.	.43041E-04
57700.	.43690E-04
57750.	.44342E-04
57800.	.44998E-04
57850.	.45658E-04
57900.	.46321E-04
57950.	.46986E-04
58000.	.47655E-04
58050.	.48327E-04
58100.	.49002E-04
58150.	.49679E-04
58200.	.50359E-04
58250.	.51042E-04
58300.	.51727E-04
58350.	.52414E-04
58400.	.53104E-04
58450.	.53795E-04
58500.	.54489E-04
58550.	.55184E-04
58600.	.55881E-04
58650.	.56579E-04
58700.	.57279E-04
58750.	.57981E-04
58800.	.58683E-04
58850.	.59387E-04
58900.	.60092E-04
58950.	.60797E-04
59000.	.61504E-04
59050.	.62211E-04
59100.	.62918E-04
59150.	.63626E-04
59200.	.64334E-04
59250.	.65043E-04
59300.	.65751E-04
59350.	.66459E-04
59400.	.67167E-04
59450.	.67875E-04
59500.	.68583E-04
59550.	.69289E-04
59600.	.69995E-04
59650.	.70701E-04
59700.	.71405E-04
59750.	.72109E-04
59800.	.72811E-04
59850.	.73512E-04
59900.	.74212E-04
59950.	.74910E-04
60000.	.75606E-04
60050.	.76301E-04

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
60100.	.76994E-04
60150.	.77686E-04
60200.	.78375E-04
60250.	.79062E-04
60300.	.79747E-04
60350.	.80429E-04
60400.	.81110E-04
60450.	.81787E-04
60500.	.82462E-04
60550.	.83134E-04
60600.	.83804E-04
60550.	.84470E-04
60700.	.85134E-04
60750.	.85794E-04
60800.	.86451E-04
60850.	.87105E-04
60900.	.87756E-04
60950.	.88403E-04
61000.	.89047E-04
61050.	.89687E-04
61100.	.90323E-04
61150.	.90955E-04
61200.	.91584E-04
61250.	.92209E-04
61300.	.92830E-04
61350.	.93447E-04
61400.	.94059E-04
61450.	.94668E-04
61500.	.95272E-04
61550.	.95872E-04
61600.	.96467E-04
61650.	.97059E-04
61700.	.97645E-04
61750.	.98227E-04
61800.	.98805E-04
61850.	.99378E-04
61900.	.99946E-04
61950.	.10051E-03
62000.	.10107E-03
62050.	.10162E-03
62100.	.10217E-03
62150.	.10271E-03
62200.	.10325E-03
62250.	.10379E-03
62300.	.10432E-03
62350.	.10484E-03
62400.	.10536E-03
62450.	.10587E-03
62500.	.10638E-03
62550.	.10689E-03
62600.	.10739E-03
62650.	.10788E-03
62700.	.10837E-03
62750.	.10885E-03
62800.	.10933E-03
62850.	.10980E-03
62900.	.11027E-03
62950.	.11073E-03
63000.	.11119E-03
63050.	.11164E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
63100.	.11208E-03
63150.	.11253E-03
63200.	.11296E-03
63250.	.11339E-03
63300.	.11382E-03
63350.	.11424E-03
63400.	.11465E-03
63450.	.11506E-03
63500.	.11547E-03
63550.	.11587E-03
63500.	.11626E-03
63650.	.11665E-03
63700.	.11703E-03
63750.	.11741E-03
63800.	.11778E-03
63850.	.11815E-03
63900.	.11851E-03
63950.	.11887E-03
64000.	.11922E-03
64050.	.11957E-03
64100.	.11991E-03
64150.	.12025E-03
64200.	.12058E-03
64250.	.12091E-03
64300.	.12124E-03
64350.	.12155E-03
64400.	.12187E-03
64450.	.12218E-03
64500.	.12248E-03
64550.	.12278E-03
64600.	.12307E-03
64650.	.12336E-03
64700.	.12365E-03
64750.	.12393E-03
64800.	.12420E-03
64850.	.12447E-03
64900.	.12474E-03
64950.	.12500E-03
65000.	.12526E-03
65050.	.12551E-03
65100.	.12576E-03
65150.	.12601E-03
65200.	.12625E-03
65250.	.12649E-03
65300.	.12672E-03
65350.	.12695E-03
65400.	.12717E-03
65450.	.12739E-03
65500.	.12761E-03
65550.	.12782E-03
65600.	.12803E-03
65650.	.12823E-03
65700.	.12843E-03
65750.	.12863E-03
65800.	.12882E-03
65850.	.12901E-03
65900.	.12920E-03
65950.	.12938E-03
66000.	.12956E-03
66050.	.12973E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
66100.	.12990E-03
66150.	.13007E-03
66200.	.13024E-03
66250.	.13040E-03
66300.	.13056E-03
66350.	.13071E-03
66400.	.13086E-03
66450.	.13101E-03
66500.	.13116E-03
66550.	.13130E-03
66600.	.13144E-03
66650.	.13157E-03
66700.	.13171E-03
66750.	.13184E-03
66800.	.13197E-03
66850.	.13209E-03
66900.	.13221E-03
66950.	.13233E-03
67000.	.13245E-03
67050.	.13256E-03
67100.	.13268E-03
67150.	.13278E-03
67200.	.13289E-03
67250.	.13299E-03
67300.	.13310E-03
67350.	.13319E-03
67400.	.13329E-03
67450.	.13339E-03
67500.	.13348E-03
67550.	.13357E-03
67600.	.13365E-03
67650.	.13374E-03
67700.	.13382E-03
67750.	.13390E-03
67800.	.13398E-03
67850.	.13406E-03
67900.	.13413E-03
67950.	.13420E-03
68000.	.13427E-03
68050.	.13434E-03
68100.	.13441E-03
68150.	.13447E-03
68200.	.13454E-03
68250.	.13460E-03
68300.	.13465E-03
68350.	.13471E-03
68400.	.13477E-03
68450.	.13482E-03
68500.	.13487E-03
68550.	.13492E-03
68600.	.13497E-03
68650.	.13501E-03
68700.	.13506E-03
68750.	.13510E-03
68800.	.13514E-03
68850.	.13518E-03
68900.	.13522E-03
68950.	.13526E-03
69000.	.13529E-03
69050.	.13532E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
69100.	.13535E-03
69150.	.13538E-03
69200.	.13541E-03
69250.	.13544E-03
69300.	.13546E-03
69350.	.13548E-03
69400.	.13551E-03
69450.	.13553E-03
69500.	.13554E-03
69550.	.13556E-03
69600.	.13557E-03
69650.	.13559E-03
69700.	.13560E-03
69750.	.13561E-03
69800.	.13562E-03
69850.	.13562E-03
69900.	.13563E-03
69950.	.13563E-03
70000.	.13563E-03
70050.	.13563E-03
70100.	.13563E-03
70150.	.13563E-03
70200.	.13562E-03
70250.	.13562E-03
70300.	.13561E-03
70350.	.13560E-03
70400.	.13559E-03
70450.	.13557E-03
70500.	.13556E-03
70550.	.13554E-03
70600.	.13552E-03
70650.	.13550E-03
70700.	.13547E-03
70750.	.13545E-03
70800.	.13542E-03
70850.	.13539E-03
70900.	.13536E-03
70950.	.13533E-03
71000.	.13529E-03
71050.	.13525E-03
71100.	.13521E-03
71150.	.13517E-03
71200.	.13512E-03
71250.	.13508E-03
71300.	.13503E-03
71350.	.13498E-03
71400.	.13492E-03
71450.	.13487E-03
71500.	.13481E-03
71550.	.13474E-03
71600.	.13468E-03
71650.	.13461E-03
71700.	.13454E-03
71750.	.13447E-03
71800.	.13440E-03
71850.	.13432E-03
71900.	.13424E-03
71950.	.13415E-03
72000.	.13407E-03
72050.	.13398E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
72100.	.13388E-03
72150.	.13379E-03
72200.	.13369E-03
72250.	.13358E-03
72300.	.13348E-03
72350.	.13337E-03
72400.	.13326E-03
72450.	.13314E-03
72500.	.13302E-03
72550.	.13290E-03
72600.	.13277E-03
72650.	.13264E-03
72700.	.13251E-03
72750.	.13237E-03
72800.	.13222E-03
72850.	.13208E-03
72900.	.13193E-03
72950.	.13177E-03
73000.	.13162E-03
73050.	.13145E-03
73100.	.13129E-03
73150.	.13112E-03
73200.	.13094E-03
73250.	.13076E-03
73300.	.13058E-03
73350.	.13039E-03
73400.	.13020E-03
73450.	.13000E-03
73500.	.12980E-03
73550.	.12959E-03
73600.	.12938E-03
73650.	.12916E-03
73700.	.12894E-03
73750.	.12871E-03
73800.	.12848E-03
73850.	.12824E-03
73900.	.12800E-03
73950.	.12776E-03
74000.	.12750E-03
74050.	.12725E-03
74100.	.12698E-03
74150.	.12672E-03
74200.	.12644E-03
74250.	.12617E-03
74300.	.12588E-03
74350.	.12559E-03
74400.	.12530E-03
74450.	.12500E-03
74500.	.12469E-03
74550.	.12438E-03
74600.	.12406E-03
74650.	.12374E-03
74700.	.12341E-03
74750.	.12307E-03
74800.	.12273E-03
74850.	.12239E-03
74900.	.12203E-03
74950.	.12168E-03
75000.	.12131E-03
75050.	.12094E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
75100.	.12057E-03
75150.	.12019E-03
75200.	.11980E-03
75250.	.11941E-03
75300.	.11901E-03
75350.	.11860E-03
75400.	.11819E-03
75450.	.11777E-03
75500.	.11735E-03
75550.	.11692E-03
75600.	.11649E-03
75650.	.11605E-03
75700.	.11560E-03
75750.	.11515E-03
75800.	.11469E-03
75850.	.11422E-03
75900.	.11375E-03
75950.	.11328E-03
76000.	.11279E-03
76050.	.11231E-03
76100.	.11181E-03
76150.	.11131E-03
76200.	.11081E-03
76250.	.11030E-03
76300.	.10978E-03
76350.	.10926E-03
76400.	.10873E-03
76450.	.10820E-03
76500.	.10766E-03
76550.	.10712E-03
76600.	.10657E-03
76550.	.10602E-03
76700.	.10546E-03
76750.	.10489E-03
76800.	.10432E-03
76850.	.10375E-03
76900.	.10317E-03
76950.	.10258E-03
77000.	.10199E-03
77050.	.10140E-03
77100.	.10080E-03
77150.	.10020E-03
77200.	.99588E-04
77250.	.98975E-04
77300.	.98358E-04
77350.	.97737E-04
77400.	.97111E-04
77450.	.96481E-04
77500.	.95848E-04
77550.	.95210E-04
77600.	.94568E-04
77650.	.93923E-04
77700.	.93274E-04
77750.	.92622E-04
77800.	.91966E-04
77850.	.91306E-04
77900.	.90644E-04
77950.	.89978E-04
78000.	.89309E-04
78050.	.88637E-04

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
78100.	.87963E-04
78150.	.87285E-04
78200.	.86605E-04
78250.	.85923E-04
78300.	.85238E-04
78350.	.84551E-04
78400.	.83861E-04
78450.	.83170E-04
78500.	.82476E-04
78550.	.31781E-04
78500.	.81084E-04
78650.	.80386E-04
78700.	.79686E-04
78750.	.78984E-04
78800.	.78282E-04
78850.	.77578E-04
78900.	.76874E-04
78950.	.76168E-04
79000.	.75462E-04
79050.	.74755E-04
79100.	.74047E-04
79150.	.73339E-04
79200.	.72631E-04
79250.	.71923E-04
79300.	.71214E-04
79350.	.70506E-04
79400.	.69798E-04
79450.	.69090E-04
79500.	.68383E-04
79550.	.67676E-04
79600.	.66970E-04
79650.	.66265E-04
79700.	.65560E-04
79750.	.64857E-04
79800.	.64155E-04
79850.	.63454E-04
79900.	.62754E-04
79950.	.62056E-04
80000.	.61359E-04
80050.	.60654E-04
80100.	.59971E-04
80150.	.59280E-04
80200.	.58591E-04
80250.	.57904E-04
80300.	.57219E-04
80350.	.56536E-04
80400.	.55856E-04
80450.	.55179E-04
80500.	.54504E-04
80550.	.53832E-04
80600.	.53162E-04
80650.	.52496E-04
80700.	.51832E-04
80750.	.51172E-04
80800.	.50515E-04
80850.	.49861E-04
80900.	.49210E-04
80950.	.48563E-04
81000.	.47919E-04
81050.	.47279E-04

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
81100.	.46643E-04
81150.	.46010E-04
81200.	.45382E-04
81250.	.44757E-04
81300.	.44136E-04
81350.	.43519E-04
81400.	.42907E-04
81450.	.42298E-04
81500.	.41694E-04
81550.	.41094E-04
81600.	.40498E-04
81650.	.39907E-04
81700.	.39321E-04
81750.	.38739E-04
81800.	.38161E-04
81850.	.37588E-04
81900.	.37020E-04
81950.	.36457E-04
82000.	.35898E-04
82050.	.35344E-04
82100.	.34795E-04
82150.	.34251E-04
82200.	.33712E-04
82250.	.33178E-04
82300.	.32649E-04
82350.	.32124E-04
82400.	.31605E-04
82450.	.31091E-04
82500.	.30582E-04
82550.	.30079E-04
82600.	.29580E-04
82650.	.29087E-04
82700.	.28598E-04
82750.	.28115E-04
82800.	.27638E-04
82850.	.27165E-04
82900.	.26698E-04
82950.	.26236E-04
83000.	.25779E-04
83050.	.25327E-04
83100.	.24881E-04
83150.	.24440E-04
83200.	.24004E-04
83250.	.23574E-04
83300.	.23148E-04
83350.	.22728E-04
83400.	.22314E-04
83450.	.21904E-04
83500.	.21500E-04
83550.	.21101E-04
83600.	.20707E-04
83550.	.20318E-04
83700.	.19935E-04
83750.	.19556E-04
83800.	.19183E-04
83850.	.18815E-04
83900.	.18452E-04
83950.	.18094E-04
84000.	.17742E-04
84050.	.17394E-04

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
84100.	.17051E-04
84150.	.16713E-04
84200.	.16381E-04
84250.	.16053E-04
84300.	.15730E-04
84350.	.15412E-04
84400.	.15098E-04
84450.	.14790E-04
84500.	.14486E-04
84550.	.14187E-04
84500.	.13893E-04
84650.	.13603E-04
84700.	.13318E-04
84750.	.13038E-04
84800.	.12762E-04
84350.	.12491E-04
84900.	.12224E-04
84950.	.11962E-04
85000.	.11704E-04
85050.	.11450E-04
85100.	.11201E-04
85150.	.10956E-04
85200.	.10715E-04
85250.	.10479E-04
85300.	.10246E-04
85350.	.10018E-04
85400.	.97937E-05
85450.	.95735E-05
85500.	.93573E-05
85550.	.91450E-05
85600.	.89365E-05
85650.	.87320E-05
85700.	.85312E-05
85750.	.83342E-05
85800.	.81408E-05
85850.	.79512E-05
85900.	.77651E-05
85950.	.75826E-05
86000.	.74037E-05
86050.	.72282E-05
86100.	.70561E-05
86150.	.68875E-05
86200.	.67222E-05
86250.	.65601E-05
86300.	.64013E-05
86350.	.62458E-05
86400.	.60933E-05
86450.	.59440E-05
86500.	.57978E-05
86550.	.56545E-05
86600.	.55143E-05
86650.	.53769E-05
86700.	.52425E-05
86750.	.51109E-05
86800.	.49821E-05
86850.	.48560E-05
86900.	.47327E-05
86950.	.46120E-05
87000.	.44939E-05
87050.	.43785E-05

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
87100.	.42655E-05
87150.	.41551E-05
87200.	.40471E-05
87250.	.39415E-05
87300.	.38382E-05
87350.	.37374E-05
87400.	.36387E-05
87450.	.35424E-05
87500.	.34482E-05
87550.	.33562E-05
87600.	.32664E-05
87650.	.31786E-05
87700.	.30929E-05
87750.	.30091E-05
87800.	.29274E-05
87850.	.28476E-05
87900.	.27697E-05
87950.	.26936E-05
88000.	.26194E-05
88050.	.25470E-05
88100.	.24764E-05
88150.	.24074E-05
88200.	.23402E-05
88250.	.22746E-05
88300.	.22106E-05
88350.	.21482E-05
88400.	.20874E-05
88450.	.20280E-05
88500.	.19702E-05
88550.	.19139E-05
88600.	.18589E-05
88650.	.18054E-05
88700.	.17533E-05
88750.	.17024E-05
88800.	.16529E-05
88850.	.16047E-05
88900.	.15578E-05
88950.	.15120E-05
89000.	.14675E-05
89050.	.14241E-05
89100.	.13819E-05
89150.	.13408E-05
89200.	.13008E-05
89250.	.12619E-05
89300.	.12240E-05
89350.	.11872E-05
89400.	.11513E-05
89450.	.11164E-05
89500.	.10825E-05
89550.	.10495E-05
89600.	.10174E-05
89650.	.98622E-06
89700.	.95588E-06
89750.	.92639E-06
89800.	.89773E-06
89850.	.86987E-06
89900.	.84280E-06
89950.	.81649E-06
90000.	.79092E-06
90050.	.76609E-06

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
90100.	.74197E-06
90150.	.71853E-06
90200.	.69578E-06
90250.	.67368E-06
90300.	.65222E-06
90350.	.63138E-06
90400.	.61116E-06
90450.	.59153E-06
90500.	.57247E-06
90550.	.55398E-06
90600.	.53603E-06
90650.	.51862E-06
90700.	.50173E-06
90750.	.48534E-06
90800.	.46944E-06
90850.	.45403E-06
90900.	.43907E-06
90950.	.42458E-06
91000.	.41052E-06
91050.	.39689E-06
91100.	.38368E-06
91150.	.37088E-06
91200.	.35847E-06
91250.	.34644E-06
91300.	.33479E-06
91350.	.32350E-06
91400.	.31256E-06
91450.	.30196E-06
91500.	.29170E-06
91550.	.28176E-06
91600.	.27214E-06
91650.	.26281E-06
91700.	.25379E-06
91750.	.24505E-06
91800.	.23660E-06
91850.	.22841E-06
91900.	.22049E-06
91950.	.21283E-06
92000.	.20541E-06
92050.	.19823E-06
92100.	.19129E-06
92150.	.18457E-06
92200.	.17807E-06
92250.	.17179E-06
92300.	.16572E-06
92350.	.15984E-06
92400.	.15416E-06
92450.	.14867E-06
92500.	.14336E-06
92550.	.13823E-06
92600.	.13327E-06
92650.	.12848E-06
92700.	.12385E-06
92750.	.11937E-06
92800.	.11505E-06
92850.	.11087E-06
92900.	.10684E-06
92950.	.10294E-06
93000.	.99181E-07
93050.	.95548E-07

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
93100.	.92040E-07
93150.	.88654E-07
93200.	.85384E-07
93250.	.82228E-07
93300.	.79182E-07
93350.	.76242E-07
93400.	.73405E-07
93450.	.70668E-07
93500.	.68027E-07
93550.	.65479E-07
93600.	.63021E-07
93650.	.60650E-07
93700.	.58363E-07
93750.	.56158E-07
93800.	.54032E-07
93850.	.51981E-07
93900.	.50005E-07
93950.	.48099E-07
94000.	.46262E-07
94050.	.44492E-07
94100.	.42786E-07
94150.	.41141E-07
94200.	.39557E-07
94250.	.38031E-07
94300.	.36560E-07
94350.	.35143E-07
94400.	.33779E-07
94450.	.32464E-07
94500.	.31199E-07
94550.	.29980E-07
94600.	.28806E-07
94650.	.27676E-07
94700.	.26588E-07
94750.	.25541E-07
94800.	.24533E-07
94850.	.23563E-07
94900.	.22630E-07
94950.	.21731E-07
95000.	.20867E-07
95050.	.20035E-07
95100.	.19235E-07
95150.	.18465E-07
95200.	.17725E-07
95250.	.17013E-07
95300.	.16329E-07
95350.	.15670E-07
95400.	.15037E-07
95450.	.14428E-07
95500.	.13843E-07
95550.	.13281E-07
95600.	.12740E-07
95650.	.12221E-07
95700.	.11721E-07
95750.	.11242E-07
95800.	.10781E-07
95850.	.10338E-07
95900.	.99121E-08
95950.	.95033E-08
96000.	.91107E-08
96050.	.87336E-08

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
96100.	.83714E-08
96150.	.80236E-08
96200.	.76897E-08
96250.	.73691E-08
96300.	.70613E-08
96350.	.67659E-08
96400.	.64823E-08
96450.	.62101E-08
96500.	.59488E-08
96550.	.56982E-08
96600.	.54576E-08
96650.	.52268E-08
96700.	.50054E-08
96750.	.47930E-08
96800.	.45892E-08
96850.	.43938E-08
96900.	.42064E-08
96950.	.40266E-08
97000.	.38543E-08
97050.	.36890E-08
97100.	.35306E-08
97150.	.33787E-08
97200.	.32331E-08
97250.	.30935E-08
97300.	.29597E-08
97350.	.28315E-08
97400.	.27087E-08
97450.	.25910E-08
97500.	.24782E-08
97550.	.23701E-08
97600.	.22666E-08
97650.	.21675E-08
97700.	.20725E-08
97750.	.19815E-08
97800.	.18944E-08
97850.	.18110E-08
97900.	.17311E-08
97950.	.16547E-08
98000.	.15814E-08
98050.	.15114E-08
98100.	.14443E-08
98150.	.13801E-08
98200.	.13186E-08
98250.	.12598E-08
98300.	.12035E-08
98350.	.11497E-08
98400.	.10982E-08
98450.	.10489E-08
98500.	.10017E-08
98550.	.95665E-09
98600.	.91352E-09
98550.	.87227E-09
98700.	.83282E-09
98750.	.79509E-09
98800.	.75903E-09
98850.	.72454E-09
98900.	.69157E-09
98950.	.66006E-09
99000.	.62993E-09
99050.	.60114E-09

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
99100.	.57362E-09
99150.	.54732E-09
99200.	.52219E-09
99250.	.49818E-09
99300.	.47524E-09
99350.	.45332E-09
99400.	.43239E-09
99450.	.41239E-09
99500.	.39329E-09
99550.	.37504E-09
99600.	.35762E-09
99650.	.34098E-09
99700.	.32510E-09
99750.	.30993E-09
99800.	.29545E-09
99850.	.28163E-09
99900.	.26843E-09
99950.	.25583E-09
100000.	.24381E-09

OPTIONS 1,0 2,0 3,0 4,0 5,0 6,1 7,1 8,0 9,0 10,0 11,0 12,0 13,1 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0 23,0

NO OF VECTORS = 0 TIME UPPER BOUND = 1.50E+05

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
50739.	.11151E-08
50927.	.17485E-08
51115.	.27109E-08
51303.	.41561E-08
51490.	.63019E-08
51678.	.94518E-08
51866.	.14024E-07
52053.	.20588E-07
52241.	.29908E-07
52429.	.42999E-07
52616.	.61189E-07
52804.	.86199E-07
52992.	.12023E-06
53180.	.16604E-06
53367.	.22710E-06
53555.	.30764E-06
53743.	.41282E-06
53930.	.54881E-06
54118.	.72292E-06
54306.	.94367E-06
54494.	.12208E-05
54681.	.15656E-05
54869.	.19902E-05
55057.	.25085E-05
55244.	.31353E-05
55432.	.38862E-05
55620.	.47778E-05
55808.	.58269E-05
55995.	.70504E-05
56183.	.84647E-05
56371.	.10086E-04
56558.	.11927E-04
56746.	.14001E-04
56934.	.16318E-04
57122.	.18884E-04
57309.	.21702E-04
57497.	.24773E-04
57685.	.28091E-04
57872.	.31647E-04
58060.	.35430E-04
58248.	.39420E-04
58436.	.43597E-04
58623.	.47935E-04
58811.	.52407E-04
58999.	.56981E-04
59186.	.61626E-04
59374.	.66306E-04
59562.	.70987E-04
59750.	.75635E-04
59937.	.80218E-04
60125.	.84703E-04
60313.	.89061E-04
60500.	.93267E-04
69688.	.97297E-04
60976.	.10113E-03
61063.	.10476E-03
61251.	.10816E-03
61439.	.11133E-03
61627.	.11427E-03
61814.	.11698E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
62002.	.11945E-03
62190.	.12169E-03
62377.	.12372E-03
62565.	.12553E-03
62753.	.12715E-03
62941.	.12858E-03
63128.	.12985E-03
63316.	.13095E-03
63504.	.13191E-03
63691.	.13273E-03
63879.	.13345E-03
64067.	.13405E-03
64255.	.13457E-03
64442.	.13500E-03
64630.	.13537E-03
64818.	.13567E-03
65005.	.13592E-03
65193.	.13613E-03
65381.	.13630E-03
65569.	.13644E-03
65756.	.13656E-03
65944.	.13665E-03
66132.	.13672E-03
66319.	.13678E-03
66507.	.13682E-03
66695.	.13686E-03
66883.	.13689E-03
67070.	.13691E-03
67258.	.13693E-03
67446.	.13694E-03
67633.	.13695E-03
67821.	.13696E-03
68009.	.13697E-03
68197.	.13697E-03
68384.	.13698E-03
68572.	.13698E-03
68760.	.13698E-03
68947.	.13698E-03
69135.	.13698E-03
69323.	.13698E-03
69511.	.13698E-03
69698.	.13699E-03
69885.	.13699E-03
70074.	.13699E-03
70261.	.13699E-03
70449.	.13699E-03
70637.	.13699E-03
70824.	.13698E-03
71012.	.13698E-03
71200.	.13698E-03
71388.	.13698E-03
71575.	.13698E-03
71763.	.13697E-03
71951.	.13697E-03
72138.	.13696E-03
72326.	.13695E-03
72514.	.13694E-03
72702.	.13691E-03
72889.	.13689E-03
73077.	.13685E-03

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
73265.	.13679E-03
73452.	.13673E-03
73540.	.13663E-03
73828.	.13652E-03
74016.	.13636E-03
74203.	.13617E-03
74391.	.13592E-03
74579.	.13562E-03
74766.	.13524E-03
74954.	.13477E-03
75142.	.13421E-03
75330.	.13353E-03
75517.	.13271E-03
75705.	.13175E-03
75893.	.13063E-03
76080.	.12932E-03
76268.	.12781E-03
76456.	.12609E-03
76544.	.12415E-03
76831.	.12197E-03
77019.	.11954E-03
77207.	.11686E-03
77394.	.11392E-03
77582.	.11074E-03
77770.	.10731E-03
77958.	.10365E-03
78145.	.99772E-04
78333.	.95694E-04
78521.	.91441E-04
78708.	.87038E-04
78896.	.82516F-04
79084.	.77906E-04
79271.	.73241E-04
79459.	.68556E-04
79647.	.63885E-04
79835.	.59263E-04
80022.	.54721E-04
80210.	.50290E-04
80398.	.45998E-04
80585.	.41869E-04
80773.	.37925E-04
80961.	.34183E-04
81149.	.30658E-04
81336.	.27359E-04
81524.	.24292E-04
81712.	.21460E-04
81899.	.18862E-04
82087.	.16494E-04
82275.	.14350E-04
82463.	.12420E-04
82650.	.10695E-04
82838.	.91627E-05
83026.	.78095E-05
83213.	.66222E-05
83401.	.55867E-05
83589.	.46890E-05
83777.	.39155E-05
83964.	.32531E-05
84152.	.26890E-05
84340.	.22115E-05

RADIONUCLIDE DISCHARGE RATE (CI/DAY)

YEAR	AA100
84527.	.18096E-05
84715.	.14733E-05
84903.	.11935E-05
85091.	.96209E-06
85278.	.77167E-06
85466.	.61589E-06
85654.	.48915E-06
85841.	.38659E-06
86029.	.30405E-06
86217.	.23797E-06
86405.	.18536E-06
86592.	.14369E-06
86780.	.11086E-06
86968.	.85125E-07
87155.	.65057E-07
87343.	.49488E-07
87531.	.37470E-07
87719.	.28239E-07
87906.	.21185E-07
88094.	.15821E-07
88282.	.11761E-07
88469.	.87037E-08

DIM / STC

New Right Hand Page

Notebook Divider Should Read. S.P. 6 - User Problem

Sample Problem 6 User Problem: Establish space and time steps for DVM calculation

Problem 6 allows the user to establish the space and time steps for a DVM calculation. Input consists of the network properties and decay chain of problem 2 with the exception of KD_S.

Isotope	$KD(ft^3/lb)$
NP237	2.0
U233	0.8
TH229	0.2

The DVM option is to be used with the reader choosing appropriate values for DX and DT. Also, the choice of TUB, the upper bound time, is left to the reader.

To aid in the determination of DX, DT, and TUB, some of the following information may be helpful.

Distances

Path length = 142500 ft

Source length = 8000 ft

Dispersivity = 500 ft

Average Velocities

Unretarded = 74.6 ft/Y

NP237 = 1.01 ft/Y

U233 = 2.48 ft/Y

TH229 = 9.01 ft/Y

Times

Leach duration = 100000 Y

Release time = 0 Y

Half-life NP237 = 2.14×10^6 Y

Half-life U233 = 1.62×10^5 Y

Half-life TH229 = 7.30×10^3 Y

A set of input and output for Problem 6 is contained in Appendix A.

DVM / STC

New Right Hand Page:

Notebook Divider Should Read: App. A -- S.P.G. Input and Output

Appendix A:

A Set of Sample Problem 6

Input Data and Output

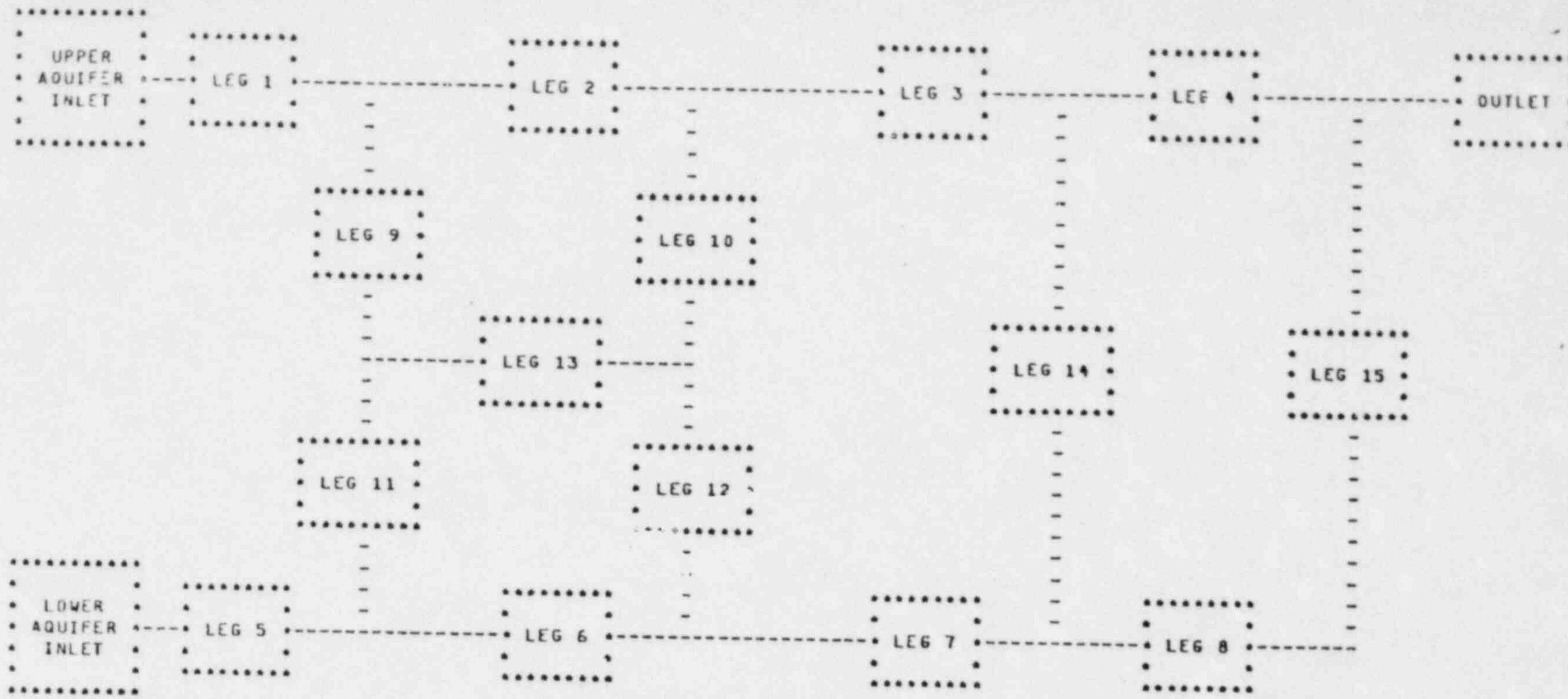
Table 13-SP (Appendix A). Sample Problem 6 Input Data

```
               SAMPLE PROBLEM NO. 6
                                                                                          BC  1
  432.70    646.10    432.70                                                              BC  2
    50.0      50.0      50.0      50.0                                                    BC  3
      .1       10.  1.67E-6    1.5E-6     40.0      40.0      40.0      40.0              BC  4
   6.E6      6.E6      6.E6      6.E6      10.   1.57E-6      2.5                         BC  4
    707.       1.0       1.        1.0   1.8E6     1.8E6     1.8E6     1.8E6              BC  5
  14500.     8000.    38000.   100000.     540.       1.     1.2E8                        BC  5
    600.     496.5      500.     603.5   14500.     8000.    38000.   100000.             BC  6
 3602.41   2502.41   1525.89   3414.81    8000.     1100.     1100.                       BC  6
 2211.31   2819.67   1719.67    425.89  3311.31   2814.81   2814.81   2314.81             BC  7
      .3        .3        .3        .3                                                    BC  7
     .15       .15       .03       .03       .3        .3        .3        .3             BC  8
      0.        0.        0.        0.       .3       .03        .3                       BC  8
    -.67        1.        1.        1.       0.        0.        0.        0.             BC  9
 4   13   10     3    4               1.        1.        1.        0.                    BC  9
 3                                                                                        BC 10
    237.     NP237         1         0   2.14E6      1.E3                                 BC 12
    233.      U233         2         1   1.62E5      1.E3                                 BC 12
       1        1.                                                                        BC 12
    229.     TH229         3         1    7.3E3      1.E3                                 BC 12
       2        1.                                                                        BC 12
                         2.0       2.0                                                    BC 12
                         0.8       0.8                                                    BC 13
                         0.2       0.2                                                    BC 13
    1.E5      500.                                                                        BC 13
                                                                                          BC 14
             3.0E5                                                                        BC 15
                                                                                          BC 18
```

```
OPTIONS 1,0  2,0  3,0  4,0  5,0  6,0  7,0  8,0  9,0 10,0 11,0 12,0 13,0 14,0 15,0 16,0 17,0 18,0 19,0 20,0 21,0 22,0  1,0
 NUMBER OF ISOTOPES    3

        ISOTOPE NAME           HALF LIFE (YEARS)      INITIAL AMOUNT (CI)

           NP237                  2.140E+06              1.000E+03
           U233                   1.620E+05              1.000E+03
           TH229                  7.300E+03              1.000E+03

        LEACH TIME =    1.000E+05 YEARS     DISPERSIVITY =   5.000E+02 FEET

NO OF VECTORS =    0 TIME UPPER BOUND =        3.00E+05
```

Table 14-SP. Sample Problem 6 Output

NETWORK FLOW MODEL



------RADIONUCLIDE MIGRATION PATH------LEGS 13 10 3 4

UPPER AQUIFER INLET
INLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 3602.41 FT

LOWER AQUIFER INLET
INLET PRESSURE = 93038.40 LB/FT**2
ELEVATION = 2502.41 FT

OUTLET
OUTLET PRESSURE = 62308.80 LB/FT**2
ELEVATION = 1525.89 FT

ELEVATIONS OF OTHER POINTS
JUNCTION 4 (LEGS 1-2-9) = 3414.81 FT
JUNCTION 5 (LEGS 2-3-10) = 3311.31 FT
JUNCTION 6 (LEGS 9-11-13) = 2814.81 FT
JUNCTION 7 (LEGS 10-12-13) = 2814.81 FT
JUNCTION 8 (LEGS 5-6-11) = 2314.81 FT
JUNCTION 9 (LEGS 6-7-12) = 2211.31 FT
JUNCTION10 (LEGS 3-4-14) = 2819.67 FT
JUNCTION11 (LEGS 7-8-14) = 1719.67 FT
JUNCTION12 (LEGS 8-15) = 425.89 FT

LEG PROPERTIES

LEG 1
****

LENGTH = 1.45E+04 FT
AREA = 6.00E+06 FT**2

Table 14-SP. (cont'd) Sample Problem 6 Output

```
      CONDUCTIVITY =  1.83E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP

            LEG PROPERTIES

LEG  2
********
            LENGTH =  8.00E+03 FT
              AREA =  6.00E+06 FT**2
      CONDUCTIVITY =  1.83E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP

            LEG PROPERTIES

LEG  3
********
            LENGTH =  3.80E+04 FT
              AREA =  6.00E+06 FT**2
      CONDUCTIVITY =  1.83E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP

            LEG PROPERTIES

LEG  4
********
            LENGTH =  1.00E+05 FT
              AREA =  6.00E+06 FT**2
      CONDUCTIVITY =  1.83E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP

            LEG PROPERTIES

LEG  5
********
            LENGTH =  1.45E+04 FT
              AREA =  1.80E+06 FT**2
      CONDUCTIVITY =  1.46E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP

            LEG PROPERTIES

LEG  6
********
            LENGTH =  8.00E+03 FT
              AREA =  1.80E+06 FT**2
      CONDUCTIVITY =  1.46E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP

            LEG PROPERTIES

LEG  7
********
            LENGTH =  3.80E+04 FT
              AREA =  1.80E+06 FT**2
      CONDUCTIVITY =  1.46E+04 FT/YR
          POROSITY =   .3000
      ROCK DENSITY =  1.19E+02 LB/FT**3
     FLUID DENSITY =  6.23E+01 LB/FT**3
   FLUID VISCOSITY =  1.00E+00 CP
```

Table 14-SP. (cont'd) Sample Problem 6 Output

```
LEG  8         LENGTH =  1.00E+05 FT
********         AREA =  1.80E+06 FT**2
         CONDUCTIVITY =  1.46E+04 FT/YR
             POROSITY =   .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  6.23E+01 LB/FT**3
      FLUID VISCOSITY =  1.00E+00 CP

              LEG PROPERTIES

LEG  9         LENGTH =  6.00E+02 FT
********         AREA =  7.07E+02 FT**2
         CONDUCTIVITY =  3.65E+01 FT/YR
             POROSITY =   .1500
         ROCK DENSITY =  1.45E+02 LB/FT**3
        FLUID DENSITY =  7.02E+01 LB/FT**3
      FLUID VISCOSITY =  1.27E+00 CP

              LEG PROPERTIES

LEG 10         LENGTH =  4.97E+02 FT
********         AREA =  1.00E+00 FT**2
         CONDUCTIVITY =  3.65E+03 FT/YR
             POROSITY =   .1500
         ROCK DENSITY =  1.45E+02 LB/FT**3
        FLUID DENSITY =  7.40E+01 LB/FT**3
      FLUID VISCOSITY =  1.43E+00 CP

              LEG PROPERTIES

LEG 11         LENGTH =  5.00E+02 FT
********         AREA =  1.00E+00 FT**2
         CONDUCTIVITY =  6.10E-04 FT/YR
             POROSITY =   .0300
         ROCK DENSITY =  1.65E+02 LB/FT**3
        FLUID DENSITY =  7.40E+01 LB/FT**3
      FLUID VISCOSITY =  1.43E+00 CP

              LEG PROPERTIES

LEG 12         LENGTH =  6.04E+02 FT
********         AREA =  1.00E+00 FT**2
         CONDUCTIVITY =  5.48E-04 FT/YR
             POROSITY =   .0300
         ROCK DENSITY =  1.65E+02 LB/FT**3
        FLUID DENSITY =  7.40E+01 LB/FT**3
      FLUID VISCOSITY =  1.43E+00 CP

              LEG PROPERTIES

LEG 13         LENGTH =  8.00E+03 FT
********         AREA =  5.40E+02 FT**2
         CONDUCTIVITY =  3.65E+03 FT/YR
             POROSITY =   .3000
         ROCK DENSITY =  1.19E+02 LB/FT**3
        FLUID DENSITY =  7.40E+01 LB/FT**3
      FLUID VISCOSITY =  1.43E+00 CP

              LEG PROPERTIES

LEG 14         LENGTH =  1.10E+03 FT
********         AREA =  1.00E+00 FT**2
         CONDUCTIVITY =  5.73E-04 FT/YR
             POROSITY =   .0300
```


Table 14-SP (cont'd) Sample Problem 6 Output

ROCK DENSITY = 1.65E+02 LB/FT**3
FLUID DENSITY = 7.40E+01 LB/FT**3
FLUID VISCOSITY = 1.43E+00 CP

LEG PROPERTIES

LEG 15	LENGTH =	1.[illegible]0E+03 FT
********	AREA =	1.20E+08 FT**2
	CONDUCTIVITY =	9.13E+02 FT/YR
	POROSITY =	.3000
	ROCK DENSITY =	1.19E+02 LB/FT**3
	FLUID DENSITY =	6.23E+01 LB/FT**3
	FLUID VISCOSITY =	1.00E+00 CP

DISTRIBUTION COEFFICIENTS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	0.	0.	0.
LEG10	0.	0.	0.
LEG 3	.20000E+01	.80000E+00	.20000E+00
LEG 4	.20000E+01	.80000E+00	.20000E+00

RETARDATION FACTORS BY LEG AND BY ISOTOPE

	NP237	U233	TH229
LEG13	.10000E+01	.10000E+01	.10000E+01
LEG10	.10000E+01	.10000E+01	.10000E+01
LEG 3	.79433E+03	.31833E+03	.80333E+02
LEG 4	.79433E+03	.31833E+03	.80333E+02

LEG NO.	FLOW VOL. (CU FT)/DAY	DARCY VEL. FT/DAY	PORE VEL. FT/DAY
1	3.88E+06	6.47E-01	2.16E+00
2	3.88E+06	6.47E-01	2.16E+00
3	3.88E+06	6.47E-01	2.16E+00
4	3.88E+06	6.47E-01	2.16E+00
5	6.58E+05	3.66E-01	1.22E+00
6	6.58E+05	3.66E-01	1.22E+00
7	6.58E+05	3.66E-01	1.22E+00
8	6.58E+05	3.66E-01	1.22E+00
9	-1.02E+00	-1.45E-03	-9.65E-03
10	1.02E+00	1.02E+00	6.82E+00
11	-1.66E-06	-1.66E-06	-5.54E-05
12	-1.39E-06	-1.39E-06	-4.64E-05
13	1.02E+00	1.89E-03	6.32E-03
14	-5.83E-07	-5.83E-07	-1.94E-05
15	6.58E+05	5.48E-03	1.83E-02

TOTAL PATH LENGTH (FT) = 1.4650E+05
FROM DEPOSITORY MIDPT (FT) = 1.4250E+05
AVERAGE FLUID VELOCITY (FT/Y) = 7.4586E+01

THE SPACE STEP................ DX = 2.67855E+03 FT
THE TIME STEP................. DT = 2.65065E+03 Y
NO OF SOURCE BLKS............ NSB = 2

Table 14-SP. (contd') Sample Problem 6

VELOCITIES AND PRODUCTION FACTORS FOR EACH SUBCHAIN CONSIDERED

DAUGHTER	PARENT(S)	AVERAGE VELOCITY	DECAY/PRODUCTION FACTOR(DT)	COURANT NUMBER
NP237	(DECAY)	.10105E+01	.99914E+[illegible]	[illegible]

U233	(DECAY)	.24760E+01	.98872E+00	.24690E+01
U233	NP237	.17433E+01	.85333E-03	.17348E+01
TH229	(DECAY)	.90070E+01	.77749E+00	.89633E+01
TH229	U233	.57415E+01	.99676E-02	.57136E+01

Table 14-SP (cont'd) Sample Problem 6 Output

RADIONUCLIDE DISCHARGE RATE (CI/UNIT)

YEAR	NP237	U233	TH229
5301.	0.	0.	0.
7952.	0.	0.	0.
10603.	0.	0.	0.
13253.	0.	0.	.65353E-07
15904.	0.	0.	.35529E-05
18555.	0.	0.	.81403E-05
21205.	0.	0.	.10650E-04
23856.	0.	0.	.13275E-04
26507.	0.	0.	.16149E-04
29157.	0.	0.	.19296E-04
31808.	0.	0.	.22738E-04
34458.	0.	0.	.26500E-04
37109.	0.	.31424E-13	.30611E-04
39760.	0.	.18571E-10	.35101E-04
42410.	0.	.11934E-08	.40013E-04
45061.	0.	.23071E-07	.45402E-04
47712.	0.	.20070E-06	.51287E-04
50362.	0.	.97623E-06	.57558E-04
53013.	0.	.30487E-05	.63852E-04
55664.	0.	.67488E-05	.69579E-04
58314.	0.	.11454E-04	.74194E-04
60965.	0.	.15939E-04	.77514E-04
63616.	0.	.19297E-04	.79747E-04
66266.	0.	.21387E-04	.81279E-04
68917.	0.	.22573E-04	.82442E-04
71568.	.11651E-21	.23282E-04	.83442E-04
74218.	.59001E-19	.23793E-04	.84370E-04
76869.	.52426E-17	.24240E-04	.85262E-04
79520.	.19609E-15	.24676E-04	.86127E-04
82170.	.41333E-14	.25097E-04	.86967E-04
84821.	.56993E-13	.25527E-04	.87781E-04
87472.	.56304E-12	.25958E-04	.88569E-04
90122.	.42367E-11	.26391E-04	.89330E-04
92773.	.2[illegible]76E-10	.26827E-04	.90062E-04
95423.	.12505E-09	.27265E-04	.90765E-04
98074.	.52030E-09	.27705E-04	.91436E-04
100725.	.18660E-08	.28148E-04	.92075E-04
103375.	.58665E-08	.28592E-04	.92681E-04
106026.	.16399E-07	.29040E-04	.93251E-04
108677.	.41248E-07	.29489E-04	.93785E-04
111327.	.94313E-07	.29940E-04	.94264E-04
113978.	.19778E-06	.30391E-04	.93729E-04
116629.	.38340E-06	.30843E-04	.90398E-04
119279.	.69176E-06	.31292E-04	.86787E-04
121930.	.11689E-05	.31737E-04	.84590E-04
124581.	.18603E-05	.32173E-04	.82206E-04
127231.	.28027E-05	.32595E-04	.79530E-04
129882.	.40158E-05	.32999E-04	.76540E-04
132533.	.54965E-05	.33379E-04	.73215E-04
135183.	.72155E-05	.33731E-04	.69532E-04
137834.	.91197E-05	.34049E-04	.65464E-04
140485.	.11138E-04	.34330E-04	.60983E-04
143135.	.13190E-04	.34567E-04	.56045E-04
145786.	.15196E-04	.34709E-04	.50611E-04
148437.	.17085E-04	.34543E-04	.44699E-04
151087.	.18802E-04	.33565E-04	.38488E-04
153738.	.20311E-04	.31183E-04	.32401E-04
156388.	.21596E-04	.27318E-04	.27016E-04
159039.	.22656E-04	.22751E-04	.22783E-04
161690.	.23505E-04	.18628E-04	.19783E-04

Table 14-SP (cont'd) Sample Problem 6 Output

164340.	.24165E-04	.15657E-04	.17761E-04
166991.	.24665E-04	.13849E-04	.16344E-04
169642.	.25031E-04	.12821E-04	.15234E-04
172292.	.25292E-04	.12187E-04	.14259E-04
174943.	.25472E-04	.11705E-04	.13342E-04
177594.	.25590E-04	.11271E-04	.12457E-04
180244.	.25664E-04	.10846E-04	.11596E-04
182895.	.25707E-04	.10420E-04	.10758E-04
185546.	.25727E-04	.99917E-05	.99446E-05
188196.	.25732E-04	.95606E-05	.91563E-05
190847.	.25727E-04	.91267E-05	.83944E-05
193498.	.25716E-04	.86902E-05	.76598E-05
196148.	.25701E-04	.82511E-05	.69537E-05
198799.	.25682E-04	.78096E-05	.62775E-05
201450.	.25661E-04	.73657E-05	.56323E-05
204100.	.25635E-04	.69193E-05	.50196E-05
206751.	.25601E-04	.64706E-05	.44407E-05
209402.	.25551E-04	.60199E-05	.38970E-05
212052.	.25470E-04	.55674E-05	.33899E-05
214703.	.25335E-04	.51140E-05	.29206E-05
217353.	.25113E-04	.46610E-05	.24902E-05
220004.	.24764E-04	.42105E-05	.20996E-05
222655.	.24242E-04	.37652E-05	.17490E-05
225305.	.23504E-04	.33291E-05	.14384E-05
227956.	.22516E-04	.29067E-05	.11671E-05
230607.	.21260E-04	.25031E-05	.93350E-06
233257.	.19744E-04	.21237E-05	.73566E-06
235908.	.18001E-04	.17732E-05	.57089E-06
238559.	.16087E-04	.14559E-05	.43606E-06
241209.	.14075E-04	.11746E-05	.32771E-06
243860.	.12047E-04	.93056E-06	.24226E-06
246511.	.10080E-04	.72366E-06	.17612E-06
249161.	.82425E-05	.55222E-06	.12590E-06
251812.	.65868E-05	.41344E-06	.88495E-07
254463.	.51442E-05	.30367E-06	.61162E-07
257113.	.39272E-05	.21882E-06	.41566E-07
259764.	.29316E-05	.15472E-06	.27781E-07
262415.	.21406E-05	.10735E-06	.18262E-07
265065.	.15297E-05	.73118E-07	.11811E-07
267715.	.10703E-05	.48898E-07	.75158E-08
270367.	.73358E-06	.32119E-07	.47073E-08
273017.	.49281E-06	.20729E-07	.29026E-08
275668.	.32467E-06	.13149E-07	.17625E-08
278318.	.20987E-06	.82009E-08	.10542E-08
280969.	.13319E-06	.50313E-08	.62133E-09
283620.	.83021E-07	.30374E-08	.36094E-09
286270.	.50859E-07	.18051E-08	.20673E-09
288921.	.30635E-07	.10564E-08	.11678E-09
291572.	.18153E-07	.60908E-09	.65079E-10
294222.	.10587E-07	.34610E-09	.35792E-10
296873.	.60800E-08	.19389E-09	.19432E-10
299524.	.34397E-08	.10713E-09	.10417E-10
302174.	.19179E-08	.58405E-10	.55165E-11

Table 14-SP (cont'd) Sample Problem 6 Output